An empirical study of human capital on economic growth: An investigation using three indices of human capital

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Arts in International Economics and Finance
Field of Study of International Economics
Faculty of Economics
Chulalongkorn University
Academic Year 2018

การวิจัยเชิงประจักษ์ของความสัมพันธ์ระหว่างปัจจัยทุนมนุษย์ต่อการเติบโตของเศรษฐกิจ: ผลการวิเคราะห์โดย 3 ดัชนีทุนมนุษย์

น.ส.ฉานชาน ฟู

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรมหาบัณฑิต
สาขาวิชาเศรษฐศาสตร์และการเงินระหว่างประเทศ สาขาวิชาเศรษฐศาสตร์ระหว่างประเทศ
คณะเศรษฐศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2561

Thesis Title	An empirical study of human capital on economic growth: An investigation using three indices of human capital
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Field of Study	International Economics and Finance
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ฉานชาน ฟู : การวิจัยเชิงประจักษ์ของความสัมพันธ์ระหว่างปัจจัยทุนมนุษย์ต่อการเติบโตของเศรษฐกิจ: ผลการวิเคราะห์โดย 3 ดัชนีทุนมนุษย์. (An empirical study of human capital on economic growth: An investigation using three indices of human capital) อ.ที่ปรึกษาหลัก : ศ. ดร.ไพฑูรย์ ไกรพรศักดิ์

งานวิจัยนี้ได้ตรวจสอบทฤษฎีการเติบโตทางเศรฐกิจที่เพิ่มเติมจากแนวคิดของโซโล โดยได้มีการเลือก 3 ดัชนีทุนมนุษย์มาใช้ในการศึกษานี้ ดัชนีแรกคืออัตราส่วนของแรงงานที่สำเร็จการศึกษาระดับมัธยมขึ้นไป ดัชนี้ที่สองคือการวัดคุณภาพการศึกษาโดยการใช้คะแนน PISA ซึ่งเป็นการสอบวัดทักษะความรู้มาตรฐาน ที่มีการทดสอบในหลายประเทศทั่วโลก การวัดคุณภาพด้วยคะแนนการสอบมีความต่างจากการวัดด้วยอัตราการศึกษา เพราะถือเป็นแนวทางการวัดที่สะท้อนต่อความสามารถที่แท้จริงในบุคคล จึงสามารถบ่งบอกคุณภาพของแรงงานได้อย่างแม่นยำกว่า ดัชนีที่สามคือการใช้ข้อมูลจาก Penn's World Table 9.0 ที่มีการสรุปดัชนีทุนมนุษย์จากทั้งคุณภาพและปริมาณการศึกษา ในงานวิจัยนี้ยังมีการครอบคลุมถึงตัวแปรปริมาณทุนทางกายภาพเพื่อประมาณการเติบโตด้วย งานวิจัยได้ใช้สองโมเดลในการประมาณค่า โมเดลแรกเป็นภาคตัดขวางที่มีการใช้มูลจากทั้งหมด 57 ประเทศ โดยมาจากกลุ่มรายได้กลางถึงสูง 21 ประเทศ และกลุ่มรายได้สูง 36 ประเทศ มีการใช้ข้อมูลระหว่างปี 2010 ถึงปี 2016 โมเดลที่สองเป็นข้อมูลตามเวลาที่มีการใช้ข้อมูลจากทั้งหมด 46 ประเทศ ในช่วงระหว่างปี 2010 ถึงปี 2013 ผลของงานวิจัยนี้สอดคล้องกับงานวิจัยที่เคยมีมา กล่าวคือ ทั้งทุนทางกายภาพและทุนมนุษย์เป็นปัจจัยสำคัญที่ทำให้เกิดการเติบโตทางเศรฐกิจ โดยทุกดัชนีทุนมนุษย์ได้ให้ผลการทดสอบในทิศทางเดียวกัน แต่เมื่อเปรียบเทียบแล้วพบว่า ดัชนีจาก Penn's World Table มีนัยสำคัญทางสถิติสูงที่สุด ซึ่งบ่งบอกว่า การวัดปริมาณทุนมนุษย์นั้น ไม่สามารถสรุปจากจากปริมาณการศึกษาเพียงอย่างเดียว แต่จะต้องคำนึงถึงการเพิ่มความสามารถในการผลิตของแรงงานด้วย

สาขาวิชา	เศรษฐศาสตร์และการเงินระหว่างประเทศ	ลายมือชื่อนิสิต ....
ปีการศึกษา	2561	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....

6085559229 : MAJOR INTERNATIONAL ECONOMICS AND FINANCE
KEYWORD: Economic growth, Human Capital, PISA, Penn World Index of Human capital

Shan Shan Fu : An empirical study of human capital on economic growth: An investigation using three indices of human capital. Advisor: Prof. PAITOON KRAIPORNSAK, Ph.D.

This research reexamines the augmented Solow's growth model to find the relationship between human capital and economic growth by using three different proxies for human capital. The first proxy of human capital is the proportion of labor force with secondary education that has been widely used in many studies. PISA score is the second proxy to human capital. It is regarded as being quality of education because this standardized test score could directly reflect the cognitive ability of individuals. The third proxy is the human capital index constructed by Penn's World Table 9.0 that included both quantitative and qualitative aspects of human capital. The study also includes physical capital into the estimation of economic growth. The equilibrium growth model was firstly estimated based on the cross-section data of 21 middle-income countries and 36 high-income countries from 2010 to 2016. An alternative approach of estimation is the panel fixed effects model of 46 countries from 2010 to 2013 to allow different country-specific effects. Consistently with most studies, our result indicated that both physical capital and human capital are crucial factors to drive economic growth. The study found that human capital has played a positive role in economic growth in all proxies. However, it has been found that the most significant proxy is an index from Penn's. An important implication of the findings is to confirm that human capital indicator should not only deal with a number of highly educated workers but it should also cover features in labor productivity improvement in an economy.

Field of Study:	International Economics and Finance	Student's Signature ....
Academic Year:	2018	Advisor's Signature ....

ACKNOWLEDGEMENTS

I would like to express my sincerest gratitude to my adviser, Prof. Paitoon Kraipornsak for his guidance and patience. Ajarn Paitoon had describes complicated details in an easily understandable way. He had pay attention to the detail of my work and help me focus on the scope of the study by providing a lot of his time for discussion the research and teach necessary economic knowledge for this thesis. Without his assistance, I probably wouldn't have complete this research. I'm also deeply grateful to all of my committees. I appreciate the comment from the chairman, Prof. Paitoon Wiboonchutikula who gives a lot of valuable suggestions during the examination. Also thanks to Asst. Prof. Yong Yoon, the examiner committee and Asst. Prof. Bangorn Tubtimtong, the external committee who had take part in my examination. Thanks to all MAIEF program's professors who had to give precious knowledge in various economic subjects to all of us. Also thanks to Khun Lawan Thanasawangkul for taking care of MAIEF students and help us with information. Thanks my friend Khun Nawawit Kessaraphong for his English improvement and he provides a lot of help during I am live in Thailand. Finally, I sincerely thanks to my parents for their support, encouragement and honestly believe in my ability.

Shan Shan Fu

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CHAPTER 1:

Introduction

1.1 Importance of human capital

It is a well-known fact that economic growth is driven by many factors, such as physical investment, population growth, amount of population and labor force or the initial level of the country's GDP, total factor productivity, etc. However, economists still question that why some poor countries are failed to follow the high income countries, even though the growth theory had suggested that the returns of investment should be higher in poor countries. It is worth to note that some economists had inspected the role of human capital in rate of growing and found that human capital is a crucial factor in accelerating economic growth and improving GDP per capita.

In recent years, the previous literatures have suggested that the buildup of human capital can stimulate economic development with explanations from two theories. The first one is "Augmented Solow's growth theory" (Solow 1956) and the second one is endogenous growth theory (Romer 1994). The augmented Solow's growth model simply extends the capital concept by including human capital in the form of education, experience, and health as one kind of invisible capital, as both physical capital and human capital can improve the level of production. Meanwhile, the endogenous growth theory claimed that an advancement of human capital means higher innovation ability and a higher level of technological progress. Therefore, increased human capital will bring total factor productivity improving and hence increasing output and per capita income.

According to OECD, human capital is defined as "The skills, competencies, knowledges and other quality inside the in individuals or groups of person gained during their life and used to create product, ideas or service in economic market." (Brian 2007) The concept of human capital can be classified by three aspects in academic fields. The first is based on individual perspective.

According to Schultz (Schultz 1961), human capital is same with the property inside human against the concept of the labor force in traditional explanation. And the production capability of human begins in now massively bigger than all summation of all other factor. Many scholars show agreement (Beach 2009) on the argument that the ability of human being is knowledge and skills represented in each person. The second opinion focuses on human capital and the process of its accumulation. This viewpoint focuses on the way to individual attain skills and knowledge through process of education. For example, basic education, secondary education, high school and vocational school education are ways to accumulate human capital (Au, Altman et al. 2008). The third viewpoint links production and human capital. Romer (Romer 1994) states that human capital is "a fundamental source of economic growth". Sheffrin (O'sullivan and Sheffrin 2003) states that human capital denotes "the stock of knowledge and skill inside the individual in the capability to do labor to produce value of economic".

Since human capital is an abstract concept that not possible to represent directly, it is necessary to find some proxies or tools to measure human capital in a more concrete way. According to GS. Becker (Becker 1964), there are two accesses to formulate human capital, formal education and outside world training.

Many researchers suggest that human capital closely related to education. The previous research mainly uses literacy rate, enrollment ratio, year of schooling as a proxy to human capital. Another way is to utilizes outside world training, such as corporate education and on-the-job training.

In many countries, firm training accounts for a significant part of human capital stock. It is equivalently important as school education to formulate skills and knowledge. For example, education and job training provided by Japan company are treated as one of the most important reasons why Japan achieved huge economic success after the postwar period (Psacharopoulos and Arriagada 1986). However, this kind of data is difficult to collect on a worldwide scale, therefore, many researches often use school education rather job training as a proxy to human capital.

Education attainment is one of the most widely applied to quantify the stock of human capital. While the school enrolment ratio may reflect the amount of human capital, it's not always accurate because school enrolment does not fully transfer to the stock of human capital. Therefore, the labor force education level is a more appropriate way to quantify the stock of human capital (Psacharopoulos and Arriagada 1986).

Besides human capital, there are some other macroeconomic factors contributing to the growth of GDP per capita. For instance, physical capital accumulation and labor force are treated as the main force to drive economic growth in traditional growth theory (Solow 1956).

Thus, the objective of this study is to examine the association between economic growth and human capital based on data from high-income countries and upper-middle-income countries. The human capital is proxied from 3 indexes for the purpose of comparison. The study employs cross-section data and panel data to run the OLS regression and panel fixed effects model to examine how human capital and some other factors affect the growth rate of GDP per capita.

1.2 Objectives

The main objective of this study is to examine the sources of economic growth and focus on the role of human capital. The study further estimates how much the human capital contributed to the economic growth in comparison to physical capital. Secondly, we also examined the role of human capital in different income countries. Lastly, since there is no standard proxy for human capital in empirical studies, this study tries to choose a better proxy for the human capital.

1.3 Hypothesis

Among other macroeconomic factors, we believe that human capital should be one of highly significant factors contributing to economic growth. Without human capital, the growth model will be incomplete. Human capital is one kind of capital input apart from physical capital thus it should have a positive impact on output growth. According to the definition of human capital, it is closely related to education and knowledge within the worker, so we believe that the more knowledgeable the worker is, the more productive they are. Therefore, we assume that the buildup of human capital will increase aggregate output and thus bring higher economic growth in long term. We expect a positive relationship between human capital and economic growth.

In macroeconomic perspective, we expect that physical capital play an important role in promoting economic growth since it increases investment and improve productivity in different sectors. Furthermore, it creates more firms, which will lead to increased competition and efficiency within countries. Thus, we expect the positive relationship with relatively high impacts between physical capital formation and GDP per capita growth.

In terms of level of countries' development, we believe that the country with high income level will grow slower than the country that has lower income because the return from capital investment is diminishing and it leads to slower economic growth rate. That is, the country with lower income level are expected to grow faster than country with higher income level. Therefore, we expect a negative relationship between country's income and economic growth.

In addition, we examine the role of human capital in economic growth between middle income countries and high income countries. Since the high income countries may have more skill-based job than middle income countries, leading that high income countries demand more education-required job. Therefore, higher education may more demanded in high income countries than middle income countries. Thus, we expect a positive relation between human capital and economic growth in countries with high income.

Cross-section model is used for the examination of economic growth steady state equilibrium condition in the long run, while panel data model is used to distinguish any difference of country-specific effects.

1.4 Scope of the study

This study investigates the role of human capital in the standard growth model by using 3 different indicators of the human capital. Namely labor force with secondary education as proportion to total labor force; the human capital index constructed following the approach of the Penn World Table 9.0; and education quality incorporated by using PISA score were used as the human capital in the estimated model. The study will look for the appropriate proxy to human capital that integrates quality improvement labor input in the economy.

Our study covers two groups of income countries: high-income and upper-middle-income countries respectively. Due to the unavailability of data in low-income countries, our study excludes low-income countries. There are two estimation approaches used in this research, including cross-section pooled least square model and panel data fixed effects model. For cross-section data, we have 57 countries that consist of 36 high-income countries and 21 upper-middle-income countries from 2010 to 2016. For panel data, we only have 46 countries during year 2010 to 2013 due to the inaccessibility of the human capital index in Penn's World Table after 2014.

1.5 Contribution of the study

As known to all, physical capital is a crucial determinant to economic growth, but how human capital affect economic growth and what are the crucial factors to determine the income level? Our research will answer this question. The result from this research will describe the effect of education to the growth of economic, which benefits the policy maker in making a macroeconomic policy, especially in the field of education.

This study employs three proxies of human capital, namely, a labor force with secondary education, average PISA score, index of human capital combines the years of schooling and education return. By using the most update data, we try to find the most appropriate proxy to represent the human capital stock. This is different from previous study that only use single proxies to observe the effect of human capital to the growth of economic.

Our study fulfills some countries data based on the dataset provided by (Barro and Lee 2013) Barro & Lee. In many previous cross-country studies, China is often ignored due to the absence of data. In this research, we also include China in the sample to provide a more complete dataset.

The structure of this paper is organized as follows: The second part is literature review, which consists of 3 parts, including the empirical studies of human capital on economic growth, the empirical studies in the case of China and the studies on the measurement of human capital, respectively. We introduce 4 measurements of human capital, followed by school enrolment ratio, average years of schooling, education quality and lastly, introduce the human capital index from Penn's World Table. The third part is the conceptual framework and methodology. The fourth part is the results and interpretations. The last part is the conclusion.

CHAPTER 2:

Literature Review

There are 2 theoretical macroeconomic methods used to model the linkage between economic growth and human capital. The first approach used augmented Solow's Neoclassical approach. The second is the Endogenous growth theory. In this research, we will focus on augmented Solow's growth model. The model extends the concept of capital by incorporating human capital into the production function (Mankiw, Romer et al. 1992) While the endogenous model focuses on encouraging factor and spillover effects of human capital which can bring the economic growth in the long run. The approach gives the important role of education to growth of economic in two ways. First, with a higher stock of human capital, the rate of productivity growth will be higher since the consequence of human capital is also affect the level of output but also further affect the further growth rate. Second, human capital stock is connected directly with technological progress because human capital can generate more knowledge and new goods (Romer,1994).

It is important to note that human capital take part in an important role in both theories and it is one of the most important topics to understand growth of economic. In this chapter, we will review some previous research that talked about human capital and economic growth. First, we will begin with the empirical study of human capital on economic growth. Second, we will introduce the empirical studies of human capital in China. Third, we will introduce some studies on the measurement of human capital. Finally, we summarize the literature review.

2.1 Empirical study of human capital on economic growth.

The influential research proposed by Mankiw (Mankiw, Romer et al. 1992) studied whether the Solow's growth theory is reliable with the variations in international live standard. They had examined three models, the first one is "textbook Solow's model", the second is the model that include collection of human-capital to the original model. The last one is “endogenous growth and convergence" into their study respectively. The data used an annual record from the year 1960 to 1985 which comes from (Summers, Heston et al. 1988). There are three groups of countries sample used in the research, namely 98 Non-petroleum countries, 75 Intermediate group countries and 22 OECD group countries. The result from the first model found to be consistent with Solow’s Model. That is, the sign of coefficient on the rate of saving and growth rate of population are highly significant which is consistent with the prediction. Second, the variance in saving rate and growth rate of population accounts for a large part of a cross country variation in income per capita. Nevertheless, the estimated influences of saving and labor growth are bigger than the model estimates. The second model expands Solow's model by adding human capital in the model. This model uses the mean percentage of population in working age in a secondary education as a proxy of human capital. The result shows that human capital had a significant relation to growth in all three samples. The research had found that after including human capital, the size of the coefficient in physical capital is also reduced. It can explain nearly 80% cross-sectional discrepancy in income per capita in the Non-petroleum and intermediate samples. So, they conclude that by including human capital to Solow's model, the model expresses a better income difference. The third model examine the convergence estimates of Solow's theory. The result shows that after contain rate of investment and growth rate of population into the estimation, the coefficient of the starting amount of income per capita is negatively significant in every groups, which means there is evidence of convergence.

The early research had been proposed by Barro and Lee (Barro 1991). Barro and Lee had studied to find the causes the growth of economic using a cross-section country data from Summers and Heston (Summers, Heston et al. 1988) dataset. Most of the outcomes applied to year 1960 until 1985 in a cross-countries data of 98 countries. In this research, the empirical analysis used secondary school enrolment ratio (SEC 60) as a proxy of human capital. The result shows that with the enrollment ratio as constant, the coefficient on initial per capita GDP (GDP60) is highly significant with negative relation (-0.075). The results mean that a growth in per capita GDP by $1000 will reduce the rate of growth of GDP (GR6085) by 0.75 % yearly. The result also shows that per capita growth has a strong positive relationship with a higher initial amount of human capital with a given level of initial GDP per capita. The projected coefficients of PRIME60 and SEC60 (human capital proxy) are 0.0250 and 0.0305 respectively. In addition, this research also found that highly developed human capital country will also have lower birth rate and higher ratio of physical capital investment. The research also concludes that some other factors like Government consumption, high inflation, price distortions, and political instability are negatively associated to growth rate.

Followed by this previous analysis, Barro and Lee (Barro and Lee 1996) included a panel dataset up to increase the data points. Because in previous cross-section analysis, the growth rate and the other factors were processed with only one sample. This research applies to a panel data of more than hundred countries during years 1960 until 1990. They had included growth rates of real per capita GDP over a 3 time period, 1965 to 75, 1975 to 85, 1985 to 90. The estimation they used is an instrumental-variable technique. The state variables are beginning level of GDP and human capital measurement as measured from education and health. The empirical result shows that a significant positive effect on rate of growth from the years of schooling in high school and higher level for male with 25 and above (0.0118 and 0.0025), and an additional year of male upper-level schooling is estimated to increase the growth rate by a substantial 1.2 percentage per year. While male primary schooling has an insignificant effect, the estimation coefficient is -0.0005(0.0011). Therefore, growth is forecasted by male education in the upper level but not in primary level. Another surprising finding is female education at any level is not statistically significant to economic advancement. For women's primary schooling (aged 25 and over), the estimated coefficient is -0.0023(0.0046). However, some further results suggest that female education are important to other factors of economic growth, such as fertility (strong negative relation with female education). Similarly, with previous research, for a given initial GDP per capita, the growth rate is increased by when lower government spending, lower the rate of fertility, improved preservation of law, lesser inflation and increasing in openness.

Hanushek and Ludger (Hanushek and Wößmann 2007) using average school yearning (1960) and PISA score as a proxy of human capital to study the outcome of human capital on growth rate. The basic result shows that after holding the starting level of GDP per capita and schooling years constant, the PISA point has found to had substantial effect to the growth rate of real GDP per capita in 1960 to 2000 with a coefficient of 1.980. When education quality is taken into consideration, the percentage of growth variation expressed by the model (adjusted R^2) significantly increased to 0.73 from 0.25. Education quantity is statistically significant to growth of economic in a model that ignores education quality with the coefficient of 0.369. However, after including education quality into a model, the relation between schooling years and growth turns out to be insignificant with the coefficient of 0.026.

Paitoon (Kraipornsak 2009) examines the role of human capital by reconstructing a human capital index for three economic sectors (agriculture, industry, and services) in Thailand using the Mincerian's approach of wage equation to create a human capital index. The result shows that for the agriculture sector, human capital is found to be positively related to economic growth, labor was found negatively contribute to the economy. In the industry sector, human capital positively related to economic growth but insignificantly. In the services sector, labor is crucial to determine growth. human capital and TFP (Total Factor Productivity) positively but insignificantly associate to economic growth. In conclusion, TFP growth significantly take part in the long run Thailand economic growth.

In contrast, there are some other researches revealing the weak relationship between growth and educational attainment. Benhabib and Spiegel (Benhabib and Spiegel 1994) using the estimation of physical capital and human capital in aggregate cross-country data from 1965 to 1985 and run the growth accounting estimation implied from aggregate production function from Cobb-Douglas. They found that variation in physical capital are significant and positively related with variation in income. It also found correlation with variation in human capital is approximately zero. Furthermore, the result is independent with the use of human capital proxy either in Barro & Lee estimation or literacy.

Followed by the dataset of Jess Benhabib, Temple (Benhabib and Spiegel 1994) argues that OLS regression is inappropriate when considering many heterogeneous countries. His research argued that one should focus on characterizing the most essential part of the dataset rather than the whole sample, instead of using OLS, he used the least trimmed squares. The reliant on variable is the log difference of output between the year 1965 to 1985, the descriptive variables are the log difference of fixed asset, average years of schooling and labor force. The result shows nearly 3 times stronger correlation than OLS regression predicted at 0.157 in a sample of 64 countries, while the variation in years of schooling is insignificant at standard levels. The coefficient of the point estimate is 0.063. There is a prove showing that production growth is positively connected to the level of human capital. The issue that Benhabib and Spiegel (1994) found may cause from the reason that simple cross-country regression cannot detect the human capital effect due to a small size of countries, perhaps a few of unrepresentative countries in which an accumulation of human capital has no or slight effect, and this may cause a considerable impact on the overall results.

Pritchett (Pritchett 2001) used the cross-sectional data and found that education contributes fewer to growth rate than the prediction from the augmented Solow's growth model. By using two cross-section and panel data sets, the education data from Nehru (Nehru, Swanson et al. 1995) and Barro and Lee (Barro and Lee 1993) and others. Pritchett creates an estimation of the growing rate of per labor educational capital from the economic factor of earnings used by Mincers' research (Mincer 1974). The dependent variable in the regression is the growth of GDP per worker from PWT5. The results from the model showed that the estimated physical capital investment matched with the share of capital (with coefficient 0.52, t=12.8). The estimated effect of growth in educational capital on per worker GDP growth is minus and not significant (Coefficient=-0.049, t-score=1.07). Including the initial level of GDP gives no impact to the negative effect of education (coefficient=-0.038). The possible descriptions for differences in cross-countries in the effect of education on economic growth. First, in a lot of developing countries, well-educated labor tends to work in the public sector more than the private organization. Second, marginal returns to education may drop rapidly. And finally, schooling in some countries may not effective, which mean years of schooling cannot translate to skills and knowledge in the labor force. Thus, the researchers conclude that it is difficult to explain the actual impact of education on the economy.

Some researchers also found negative results when explored the correlation between education and growth of economic. Lau, Lawrence, Dean, and Larry (Lau, Jamison et al. 1991) examined the effect of education by schooling level (primary and secondary) in five continents, the results show that primary education has a negative outcome in Africa and the Middle East North Africa. The effect is insignificant in Latin America and South Asia. And significantly positive effect in East Asia. Caselli, Gerardo, Fernando (Caselli, Esquivel et al. 1996) used panel analysis to allows country-specific effects reliably. The result had shown negative relation with schooling year.

2.2 Empirical studies in the case of China

The study of human capital and economic growth had been done in some individual countries, but here we focus on China where the growth rate is substantially rising in these 3 decades.

Whalley, John, and Xiliang (Whalley and Zhao 2013) reevaluate the sources of China's growth rate with the focus on the effect of human capital stock. The first method reexamines the sources of growth by using human capital as same as in Barro and Lee (1993) researches. The result shows that human capital only response for 11.7% to GDP growth between 1978 to 2008 while human capital grew at 2.34% annually in the same period. Physical capital is the crucial force to drive growth, it contributes 44.96% to GDP growth from 1978 to 2008. Since Barro and Lee's method use the mean schooling year which doesn't differentiate productivity differences among different education levels into account. Therefore, they construct an alternative measurement of human capital as used in Schultz (1960). Schultz's take measurement of education as inputs to human capital proxy takes productivity to the calculation. The result shows that human capital have an important role in China economic growth. Human capital growth around 7.6% yearly from year 1978 to 2008. Slightly less than the growth rate of physical capital. The involvement of human capital to economic growth is 38%. The result suggested that human capital is an vital factor that previous research had concluded, but physical capital still plays a crucial role in economic growth (44.96% from 1978 to 2008).

Wang and Yao (Wang and Yao 1999) examine the determinants of China growth rate of economic using standard growth accounting method that includes value of human capital during 1953 to 1999. More precisely, from the reform period 1978-1999 and the pre-reform period 1953-1977. Following by Barro and Lee (Lee and Barro 2001), this research uses a continuous inventory methodology to construct the human capital index and the collection of human capital in China that calculated from the average schooling years in the population age ranging from 15 to 64. The empirical result shows during pre-reform era (between 1953 and 1977), the yearly output growth rate is 6.5 percent. In the pre-reform time (between 1978 and 1999), the output growth reached 9.7%. However, the involvement from fixed capital is still the highest significance determinant to growth of output, with a percentage around 56.8% and 48.3% share in the pre-reform era and reform era. As growth theory suggested, human capital contribute a significance part to growth. The contribution of human capital to growth is 32.8% in the pre-reform era and 13.8% in the reform era. The most important change is the reducing in the yearly growth rate of stock of human capital, with a drop to 2.7 percent from 5.3 percent in the period of pre-reform. After incorporating human capital, the increase rate of total factor productivity (TFP) increase from minus of -0.57 % in the pre-reform era to around 2.3% yearly in the reform period and it accounts for 23.9% of total output growth before 1978. Total factor productivity becomes a robust factor in China economic growth in the reform era. Both the growth in productivity and accumulation of factor are substantial reasons that take part in China economic growth within the period of reform.

Chuanguo Zhang and Lihuan Zhuang (Zhang and Zhuang 2011) examine the impact of the human capital composition on growth of economic in China with Generalized Methods of

Moments (GMM). 31 Provinces of data had been included between the year 1997 to 2006. The proxy of human capital used in this research is the average years of schooling. Furthermore, they decomposed two group of the average years of schooling based on levels, which are tertiary and pre-tertiary to find out whether the contribution of individual education level to the growth rate. The empirical result shows that tertiary education shows a significantly positive impact on GDP growth, but the lower level of educations is insignificant. To further investigate an effect of human capital structure to the growth, they introduce the human capital structure and its square, they also include some control variables into the model, the coefficient in structure of human capital is statistically significant and show positive value while its square found to be negative and are both. The p-value of the joint significance of the two-term is 0.07. The result indicates that growth is improving in the lower level structure of human capital. However, the relationship found to be negative if the human capital structure value is over the threshold. Overall, the structure of human capital in China is still at the early stage economic growth. With the increase in the percentage of investment, higher education will stimulate growth of the nation. The research suggested that in China, University education level is more vital than secondary and primary school to the growth.

Sai Ding, John Knight (Ding, Knight et al. 2011) attempted to find the role of human capital and physical capital to the economic growth of China. The research uses automated General-to-Specific approach along with Bayesian Model Averaging to observe the association between the growth rate of real GDP per capita and a large range of potential explanatory variables. The variables included are the initial level of income, human capital formation, physical capital, population growth, institutional change, the degree of openness, sectoral change and so on. The school enrollment ratio is used as a proxy to the human capital in this research. Among the result of the baseline model, there are three important conclusions from the work. The first is both human and physical capital collection can improve growth rate. The second is physical investment makes the most influential contribution to growth when it is matched with technological progress. Finally, the result showed that higher education level than secondary school enrollment has a help influence to the growth rate of GDP.

Belton, Li, and Zhao (Fleisher, Li et al. 2010) studied on the effects of human capital, and fixed capital and foreign direct investment (FDI) on regional inequality to the economic growth in China. They estimate the aggregate production function of provincial by specifying fixed capital and two kind of labors as an input. The two kind of labors included are educated workers (primary school and above), and less educated workers (less than primary school). The production equation is estimated in a two-way fixed effects model. This strategy allows investigating two possible channels through which human capital may influence output. The estimation result shows that human capital positively improve output in several point. First, high-skilled labor directly contributed to production. A worker who had more education than primary level will has higher productivity than a worker who had not completed a primary school education. Second, there is a positive direct effect of human capital on Total Factor Productivity growth, the possible explanation for this is it create innovation which can improve productivity in long run. Finally, there is evidence showing that an indirect spillover effect of human capital on the growth of Total Factor Productivity. Moreover, the results show that infrastructure investment will generate higher returns in developed regions, while investment in human capital creates higher returns in under-developed area. Therefore, they give the conclusion that investment in human capital in the area where it is not yet developed will greatly increase the efficiency of economic and reduce inequity.

Xianyu Chang, Yong Shi (Chang and Shi 2016) uses demographic data from 30 provinces and autonomous regions to analysis the classification and mechanism of heterogeneous effects between human capital on growth rate. This research uses years of education as a proxy of the stock of human capital. The methodology used in this paper followed Benhabib and Spiegel(1994) former cross-section model extend to the regional level, the perpetual inventory method is used to measure physical capital. Others explanatory variables include openness, government spending, and population. The empirical results show that human capital in primary school directly contributes to the increase of production while advanced education increase economic growth through innovation of new technology. Physical capital is significantly crucial factors in boosting economic growth.

Wei Chi (Wei 2008) using provincial data from 1996 to 2004. The included factor is a yearly different in the log of GDP per capita, independent variable includes population count, labor force, school attainment and physical capital. The proxy of human capital used in research is educational attainment. The estimation model consists of both cross-country and panel provincial estimation model. The empirical results show that after including provincial fixed assets investment in model, the provincial physical capital investment is meaningfully related to the growth rate, in addition, GDP per capita in the beginning time period express negative sign (-0.015,-0.021,-0.022,primary, secondary and tertiary respectively), this indicate provinces with higher initial GDP will grow slower than those the country with lower output. The results mean that local economic growth express conditional convergence by adding the physical capital investment and human capital stock. The panel growth estimates resemble with cross-country estimation. Both the accumulation and stock of human capital are both not significant to GDP per capita growth. The result is consistent with earlier work which means China economic growth is mainly motivated by fixed asset investment, the human capital has an irrelevant role in provincial economic development. However, it is probable that human capital driven economic growth may indirectly come from fixed capital investment. The empirical result shows that the higher percentage of labor with tertiary and secondary education in 1996 lead to higher physical capital accumulation between to the year 2004, with the coefficient of 0.022(0.007) and 0.113(0.021). Furthermore, consider a country's initial wealth may create huge physical capital in future, the writer adding the initial GDP per capita in model, the outcome express that (based on tertiary education) the local GDP from 1996 has a big contribution on physical assets investment during 1996 to 2004, if the starting per capita GDP increase by 1 percent, the mean annual physical capital investment per person will increase by 0.9 percent. This verifies that human capital stimulates economic growth indirectly by attracting more physical capital investment.

2.3 Studies on the measurement of human capital

One of the main problems in the empirical study of human capital to the economic growth is to account for the human capital measurement. There is some traditional measurement of human capital stock, it can roughly separate by 3 categories, namely, income-based method, output-based method and cost-based method.

For the income-based method, it is initially proposed by Theodore (Schultz 1961) , Gray Becker (Becker 1964),and Jacob Mincer (Mincer 1974). The method is depended on the returns (individual income) from investment in education that the worker gains from the labor market. Mincer's contribution is especially important. He argues that wage differences were created by skill or differences in human capital. Wage difference can be described by different education and on-the-job training (Mincer 1974). An original incentive for schooling was increasing general skills, so it is sensible to measure human capital by the amount of education. For a cost-based method, it measures the stock of human capital by adding all costs that invested in human capital. (Kwon 2009). For the output-based method, it aims to find the effect of human capital on economic growth. School enrolment ratio, average years of schooling and adult literacy are major proxies of human capital used in this approach.

In this paper, we research for the connection in growth of economic and human capital, we mainly focus on the output-based approach, thus we will give more details in the following literature review.

2.3.1 School enrolment ratio

School enrolment ratio, whether primary, secondary or tertiary are proxies of human capital that frequently used. Two types of enrollment ratio are generally used in the research, namely net enrolment ratio and gross enrolment ratio. The definition of gross enrolment ratio is the ratio of the number of students enrolled at a grade level relative to the total population of the corresponding age groups. Net enrolment ratio is a ratio of students in the official schooling age (depend on countries system) who are take part in education divided by the total number of populations in that age.

Barro and Lee (Barro 1991) using the values of education enrolment ratio in primary (1960) and secondary (1960) respectively, as two main proxies of human capital to study the economic growth. The data come from Heston and Summers (1988) and the UN, these two variables measure student enrolment number in two grade levels relative to the total population of the corresponding age group. (gross enrolment ration). The results show that primary and secondary enrollment rate has a positive relation to production per capita growth, holding constant the GDP in 1960 and other variables. The coefficient from the estimation of PRIM60 and SEC 60 are both significantly different from zero, with t-value 3.8 and 4.4 respectively.

Levine and Renelt (Levine and Renelt 1992) study the human capital impact to a growth rate of real GDP per capita. (annually from 1960 to 1989, 119 countries) using the secondary school enrolment ratio in 1960 as human capital (flow). The empirical result shows that the initial secondary school enrollment ratio enters with a significantly positive and robust coefficient related to the growth rate of per capita GDP. And another important finding is that there is a robust negative partial correlation between GNP and initial income over 1960 to 1989. The coefficient on RGDP60 is used to examine convergence property, which means a poor country tends to grow faster than the rich country. The result is consistent with Barro (1991) and Mankiw (1992), which evidence to show the conditional convergence during the year 1960 to 1989, (i.e., a robust negative correlation between GYP (the mean yearly growth rate of per capita GDP) and RGDP60(the starting level of real per capita GDP in 1960) if the regression includes the secondary enrollment ratio).

Murphy, Schleifer, and Vishny (Murphy, Shleifer et al. 1991) study the relationship between the growth rate of per capita GDP and amount of human capital, following the conceptual framework by Barro and Lee, using the similar dataset provide by Barro & Lee (Barro 1991) that extended from Summers and Heston (Summers, Heston et al. 1988). The Primary school enrolment ratio in year 1960 is a proxy of human capital and adds the college enrolments ratio in law school to entire college enrolments in year 1970 as well as engineering ratio. First, they run the regression for all 91 countries in samples and then choose for 55 countries (subsample) with have 10,000 students and more. The empirical results show that from the year 1970 to 1985, for every country, there is a positive and significant effect of number of engineering student on economic growth while a insignificant and negative (t-score=1.2) for growth and lawyers. If an additional 1 percent enrollment rate was in engineering, which corresponds to doubling mean engineering school attainment, the growth rate would increase 0.05 percent per year. Meanwhile, if an additional 1 percent was in law, the growth rate will reduce by 0.03 percent per year. In addition, the results also show that both in full sample 91 countries and subsample found that an improvement in primary enrolment rate will bring an increase in per capita GDP growth rate.

However, the School enrolment ratio as a proxy of human capital has some shortcomings. First, the enrolment ratio is a flow variable, which mean that it can use as a change of human capital over time, but not the human capital stock itself. For the economic growth study, it is more appropriate to use entire productive human capital stock, not solely flows of human capital. Second, school enrolment ratio still not counts for labor force who already join the labor market, which means it cannot reflect the flow of investment in human capital into the economically and productively human capital stock, it is more accurate in measuring the flow of investment in human capital that will become productive labor in later time. Furthermore, school enrolment ratio may omit the person who repeats a grade or drops out in middle study, and people who graduate but not take part in the labor force (Chen and Dahlman 2004). Therefore, school enrollment ratio may not be a proper indicator to represent all productive labors in the whole economy. However, it is still an inappropriate proxy to determine the relationship between human capital to the growth of economic.

2.3.2 Average years of schooling

Due to some drawbacks of enrolment ratio, recent researches choose average years of schooling or average educational attainment as a proxy of human capital instead of enrolment ratio. The average year of schooling is calculated from the average number of completed years of education in a country's population aged 25 and above. This is a better metric because it captures the true stock of human capital, not just only the flow of human capital. Moreover, it excludes the student who repeats the grade or drops out, which lead to a more accurate presentation of the education performance of the nation.

There are two global datasets on education attainment, Barro and Lee (Lee and Barro 2001) and Cohen and Soto (Cohen and Soto 2007). Barro and Lee had provided an influential dataset which had been commonly used to study human capital and growth of economic. The dataset contains information on educational attainment for people aged 15 (25) and over by gender and education level for many countries. There are seven levels of education in the census, no-schooling, complete and incomplete primary, complete and incomplete secondary, and complete and incomplete tertiary. The dataset contains 142 countries that have at least one data point and 107 countries with full data. The source of this dataset is based on school attainment data from UNESCO. The census contains about 40 percent of the available data for a panel analysis from 1960 to 1985 (2000) at a 5 years interval. They use adult non-literacy to expand the coverage of the no-schooling category beyond 40 percent. The left cells are filled with four levels (no differentiate between complete and incomplete education) by a perpetual inventory method. The method gave the census value as the standard stocks and used the school enrolment ratio to measure the flows of people into different attainment group. They found that the method better represents the income of new school entrants to the educational stock compared with the gross or net enrolment ratio. The latest study also adjusted to changes in school duration overtime into account.

The number of schooling years for the people aged more than 15, s_t , is calculated as follow:

$$st = \sum_{a=1}^{A} l_t^a \, s_t^a \qquad (1)$$

where l_t^a is the share of population of a group in population 15 and over.

s_t^a is the value of schooling years of each age group (a=1: 15-19 age group, a=2: 20-24 age group,…a=13: 75 and above)

The number of years of schooling of the age group (a) in time t is defined as follow:

$$s_t^a = \sum_j h_{j,t}^a Dur_{j,t}^a \qquad (2)$$

Where h_j^a is the share of group that have taken part the educational level j=p, s(complete, incomplete), h(complete, incomplete). The variable Dur refer to years of corresponding duration.

They used the identical data sources and method to build a panel dataset on the female school attainment grouped by age. The school attainment statistics of all combined population with the data of each country on the year of duration at different levels produce the schooling years attained by the overall person at different levels and total schooling levels.

Barro and Lee (1994) examined the sources of economic growth by using the previous dataset (Barro&Lee,1993), average years of secondary school attainment is a proxy of human capital stock, they separate the gender in this paper. The empirical result shows that man's school attainment in secondary level has a positive relationship with subsequent growth. The estimated coefficient is 0.0134, (s.e.=0.0041) which means an extra year of secondary schooling increases the growth rate by 1.34 percent per year. While the puzzling finding is that the starting level of secondary education in female show negative relation in the growth model, with the coefficient -0.0084 (s.e.=0.0045).

Cohen and Soto (2007) also constructed a new dataset of average years of schooling for cross country. This dataset includes 95 countries and during year 1960 to 2000 on a 10 years interval. The data sources come from the OECD database, UNESCO's Statistical Yearbook, and census directly taken from official web site of national statistical agencies. The OECD had public the information about educational attainment, start at the end of the 1980s. This information includes the population aged 15 to 64, divided by different age groups. The methodology used to construct the human capital index like Barro and Lee. They build the average schooling years number of each nation by multiplying amount of population share of educational attainment by the attainment length of each schooling level (1. primary, 2. secondary and 3. higher education). The length may differ among countries, which also take into consideration. Moreover, Barro and Lee don't include for rate of mortality heterogeneity along groups of ages, consider older age groups may had a more mortality rate. In many countries, young people tend to have more education than older, the forward extrapolation may underestimate the changes in years of schooling if heterogeneity of death rate is not appropriate considered into the calculation. Thus, they claimed that this dataset is more accurate than the previous one, firstly, the advantages of this dataset are the information come from OECD presented in a standard form in a cross country, this avoids the use of census based on different cataloging of education systems, and another advantage is the methodology is less measurement error compare with Barro and Lee. Overall, Cohen and Soto (2007) present a higher number of years of schooling than Barro and Lee, especially more attractive in high-income countries.

Table 1: Years of schooling comparison statistic (pop age 25 and more, averaged)

	Barro and Lee			Cohen and Soto		
	1960	1990	Difference	1960	1990	Difference
All Countries (82)	3.5(2.6)	5.6(2.9)	2.1(1.1)	3.8(2.7)	6.2(3.2)	2.5(1.1)
High income (23)	6.4(2.1)	8.7(1.9)	2.3(1.1)	7.0(1.9)	9.9(2.2)	2.9(0.5)
Low and middle income (59)	2.3(1.7)	4.4(2.2)	2.1(1.0)	2.5(1.8)	4.8(2.4)	2.3(1.2)

Standard deviation in bracket.

The data is taken from Cohen and Soto (2007) calculation.

Bassanini and Scarpetta (Bassanini and Scarpetta 2001) used a time series of human capital provided by Barro and Lee (1996) dataset. The data from the past decade had been updated with the most recent OECD dataset. The method that had been used is Pooled Mean Group (PMG) estimators to examine the long run relationship between human capital and economic growth in OECD countries over 21 years. (annual data, 1971-1998). They used the average number of years of schooling among the working age population as a proxy of human capital stock. The empirical result shows that the coefficient of average years of schooling turns out to be statistically significant at 1 percent level in the model without a time-trend. The coefficient is also still high in the specification with a linear time movement but not statistically significant. The long-run elasticity of from the overall regression express that output per average years of schooling and working-age population are significantly correlated. The estimated coefficient is around 0.6, one extra year of schooling is expected to increase output per capita by around 6 percent. And the calculated long-run effect on output also in line with econometric results on the private returns to schooling (around 8 percent). In addition, the result also shows that a significant growth outcome from the physical capital collection and converging rate to the steady-state GDP per capita growth path with yearly 15 %.

Some researcher uses labor force with different amount of education as a proxy of human capital, because it considers the real supply of human capital available for production and captures the degree where flows translate into a stock of human capital. Psacharopoulos and Arriagada (Psacharopoulos and Arriagada 1986) calculate the average year of schooling in the labor force in his paper by using labor force with different level of education. They combine two data sources, a published census (Maryland office, 66 countries) and Kaneko's data (Kaneko and Training Department 1986) (33 countries), the size of the data sample include 99 countries in all. Education are grouped by 6 levels, starting from illiterates and persons with primary incomplete, primary complete, secondary incomplete, secondary complete and tertiary education. To get mean years of schooling within the labor force, we need to know the years of duration of different levels of schooling, and then multiply the percentage of persons in the labor force with different levels of schooling. The calculation is shown as follows:

$$\bar{S} = \sum L_i S_i \tag{3}$$

Where L_i is the rate of the person in the labor force with i[th] schooling level, S_i is the duration in years of i[th] level of schooling, and i denotes for a different level of education.

In detail, this equation can rewrite as follow:

$$\bar{S} = \frac{\left[\begin{array}{c}\left(LP1*\frac{YRSP}{2}\right)+(LP2*YRSP)+\left(LS1*\left(YRSP+\frac{YRSS}{2}\right)\right)+ \\ \left(LS2*(YRSP+YRSS)\right)+\left(LH*(YRSP+YRSS+YRSH)\right)\end{array}\right]}{100} \tag{4}$$

Where:

$\bar{S}$: An average year of schooling.

LP1 : Labor force with incomplete primary schooling. (%)

LP2 : Labor force with completed primary schooling. (%)

LS1 : Labor force with incomplete secondary schooling (%)

LS2 : Labor force with completed secondary schooling

LH : Labor force with completed and uncomplete higher education

YRSP : Years of duration in primary school

YRSS : Years of duration in secondary education level

YRSH : Years of duration in higher education

Note that it is presumed that the labors with incomplete primary and incomplete secondary education attainment for half of the years in each corresponding level. For example, if the primary level in China is 6 years, then LP1 will treat as 3 years.

Another similar approach to compute the average schooling year within the labor force is using school enrolment ratio. Harbison and Myers (1964) had define a composite index of human resource development through the weighted sum of the enrolment ratios on the secondary and upper level of education. By give an example:

$$I = E_S\ (1) + \ E_H \tag{5}$$

Where E_S and E_H denote the ratio of enrolment in the secondary and higher level of education. The numbers appear in the bracket are arbitrary weights in different education levels. The writer gave a 5 of 1 weight of higher education compared to secondary level education by giving a reason that advanced knowledge should be more important than the secondary level. (Harbison and Myers 1964). Note that in their study, they give zero weight in primary education.

2.3.3 Education quality

Using the mean schooling year indirectly assumes that a year of schooling are equivalent to the increase in skill and knowledge no matter how education systems different. For example, , one-year schooling in USA result in the same value in terms of knowledge and skills a year of schooling in Africa, which is unlikely. Therefore, rather than measuring how long students stay in school, it is also important to ask how many students learned in school. This means that in comparison to education quantity, education quality may more important to reflect the education performance in one country. One of the challenges to understanding the impact of education quality on growth of economic come from the measurement of education quality.

There are two qualitative descriptions of human capital. First, measurement of schooling inputs, for example, education spending and teacher-pupil ratio. Second, measuring the cognitive skills of individuals, the advantage of cognitive skills benchmarking is it allows quality difference to come from outside of formal school. The cognitive skills measurement directly used the cognitive achievement test to measure. There are six standard international examination of student cognitive in science and mathematics that were take place in the past three decades. Two of tests are conducted by the International Assessment of Educational Progress (IAEP) and Four were conducted by the International Association for the Evaluation of Educational Achievement (IEA). The emphasis on science and mathematics correspond with the academic pay attention on the importance of development and research activities as the sources of economic development (Romer,1994). One famous cognitive test is PISA standard test. PISA standard test conducts by OECD, it tests 15 years old student around the world every three years intervals. It includes 3 subjects of tests, namely science, mathematics, and reading. The mean score is 500 with an SD of 100. The tests like PISA or IEA which take part in many countries have same standard and comparable among countries, which can use to indicate the level of cognitive skills of population among different countries.

Many researchers find that the cognitive achievement test is a good indicator of student's future earnings. (Card and Krueger 1992) (Hanushek and Wößmann 2007). Furthermore, there is evidence shows that test score is closely correlated with economic development in aggregate data.

There are some previous researches try to capture the source of quality of education. The basic dataset provided by Barro and Lee (Barro and Lee 1993) measures the years of schooling by separating between male and female student at different levels of education but doesn't take education quality into consideration. Therefore, they have compiled some proxies (Barro 1996) for the inputs of education quality for further examine the effects of education quantity and quantity on a number of variables related to economic growth. These variables include average public spending per student on educational, ratio of teacher per students, an estimated yearly income of teachers, duration of school year. The dataset also includes two variables of education outcome, student repeat rates, and dropout rates. The overall figure shows that for all developing countries, at the primary education, the pupil to teacher ratio drop from 38 to 32 during the year 1960 to 1990 while at the secondary level, this ratio is increased from 19 to 21. The spending on pupils is decreased both at the secondary and primary levels.

Barro used two datasets, previously Barro and Lee (1993) and Hanushek (Hanushek and Kimko 2000) to investigate the effect on education quality, collected by international test scores, repeat, and drop-out ratio, from family features and school resources. The result shows a significant relationship between income of family and pupil's accomplishment. The positive coefficient of the log per capita GDP (3.41, t =3.20) proved that student comes from high-income countries are more likely to get higher test scores, holding other factors constant. This suggests that parent's income had a strong positive impact on children's educational performance. Also, mean years of primary school attainment for adults (aged more than 25) have a significant positive effect on test scores. The coefficient on the schooling (1.35, t =4.9) suggests that one standard deviation increase in average years of primary schooling (1.7 years in 1990) is estimated to increase test scores by 2.3 percentage points. In addition, this paper also examines the effect of school sources, measured by pupil-teacher ratio and education expenditure, on the education outcomes. The result reveals a negative relationship between the pupil-teacher ratio and test scores. The estimated coefficient (-.22, t=2.54) confirms that one standard deviation decreases in the pupil-teacher ratio (by 12.3 in 1990) increases test score by 2.7 percentage points. However, the log of total education expenditure is insignificant (negative sign) with test scores.

Hanushek and Kimko (Hanushek and Kimko 2000) (the previous version is released in 1995) construct a cross country database of test scores for 39 countries. They discover a strong relationship of education quality (they construct new quality measurement based on student cognitive performance performed in standardized tests of academic accomplishment in science and math) on growth in average real per capita GDP from the year 1960 to 1990. The baseline model of 31 nations with full data relates growth to initial income (Y60) and measure of school quantity (Barro & Lee). Their elementary results are consistent with the previous estimation, the initial income negatively related to growth, with the coefficient -0.609, gives the indication of conditional convergence in rate of growth. The results also show that adding education quality boosts the adjusted R^2 to about 0.7, (compare with simple model 0.3). An increase of one S.D. (comparable to 47 test score of PISA mathematics in 2000) of labor force quality increases the real per capita growth rate by 1.4 percent per year. In contrast, one S.D. increase in the school quantity is related to only one of the fourth increase in annual growth. (0.26). The effects of school quantity fall substantially if the education quality is included in. Thus, they conclude that if the education quality is ignored, the economic growth model will miss the important relationship in the aspect of economic growth.

2.3.4 Human Capital Index in Penn's World Table (PWT)

For more than 40 years, Penn’s World Table (PWT) (as known as Summers-Heston dataset) has been a standard source of the database on the various economic study. It includes metrics on relative range of income, input, output, and human capital index. (Feenstra, Inklaar et al. 2013)

PWT 8.0 introduced an index of human capital per labor. The calculation is based on mean schooling years that are directly estimated from Barro and Lee, (Barro and Lee 2013), and assumed the rate of education return for primary-secondary-tertiary education from Mincer estimation over all countries. (Psacharopoulos,1994). Due to the PWT 8.0 release in July 2013, Cohen and Leker (2014) had created another dataset for average schooling which claimed that this dataset is more superior than the dataset provided by either Barro and Lee or Cohen and Soto (2007) (referred to as CSL). Therefore, PWT9.0 combines both data sources to construct the human capital index.

This dataset includes human capital for 150 countries. Most of countries (95 countries) data are based on Barro and Lee, for another 55 countries, the data are based on Cohen-Soto (Cohen and Soto 2007) (Cohen and Leker 2014). For Barro and Lee's data are only available every 5 years from 1950 to 2010 and CSL data are available only every 10 years from 1960 to 2020. Also, the Cohen’s data are not available in pre 1960 years while the lasted Barro and Lee data only until the year 2010. The CSL data include predictions up to the year 2020. The human capital dataset in PWT 9.0 is only available until the year 2014.

Table 2: Summary of cross country growth regressions results from previous researches.

Studies	Years	Dependent Variables	Measurement of Human Capital	Flow/ stock	Estimated coefficient	Interpretation findings
Mankiw, Romer, Weil (1992)	1960-1985 (annual)	Log GDP per working age population in 1985	Mean percentage of labor age population in secondary school	Period flow	0.66	An improvement of one percentage in the average working age population in secondary education will increase 0.66 % in production per labor age population
Barro &Lee (1991)	1960-1985 (annual)	Growth rate of real per capita GDP	Education enrolment rate (Secondary and Primary)	Initial flow	Primary= 0.025 Secondary =0.03	one percentage improvement in primary (secondary) school enrolment rate is related with 2.5(3.0) percent increase in GDP per person.
Barro & Lee (1996)	1965-75 1975-85 1985-90	Growth rate of real GDP per capita	Average years of schooling at the secondary and higher level for male at the start of each period	starting Stocks (in1965 1975, 1985)	0.012	Increasing male schooling (secondary and upper) is related with a 1.2 percent increase in growth of per capital GDP.
Hanushek & Kim (2000)	1960-1990	Growth rate of real GDP per capita	Mean years of secondary schooling for adult male in 1960, 65,70,75,80 And 1985	starting stock	0.54	An additional year of male secondary schooling is related to 0.54 percentage increase in growth of GDP per capita.
Hanushek & Ludger (2007)	1960-2000	Average yearly growth rate in GDP per capita	PISA test score (mean)		1.98	Test score that increase one SD (measured by student level across all countries in OECD group) is related with an average yearly growth rate of GDP per capita is 1.98%.
Levine & Renelt (1992)	1960-1989	Rate of growth of GDP per capita	Enrollment rate in Secondary school in 1960	Initial flow	2.50-3.71	With one percent secondary school enrolment ratio will increase 2.5 to 3.71 percent increase in GDP per capita growth.
Murphy and others	1970-1985	Rate of growth of GDP per	Enrollment rate of Primary school in	Initial flow	0.022	With increase one percent of primary enrolment ratio would

(1991)		capita	1960			increase the growth rate of GDP per capita 2.2 percent.
Barro &Lee (1994)	1965-1985	Rate of growth of GDP per capita	Male mean year of schooling in 1965	Initial stock	0.0134	One more year of secondary male schooling increase the growth rate by yearly 1.34 percent.
Bassanini &Scarpetta (2001)	1971-1998	Real GDP per person of working age	Mean years of schooling of the adult population	Stock	The long run elasticity of output to average years of education is 0.6	A one percent improve in average years of schooling is related to 0.6 percent increase in GDP per person.
Benhabib & Spiegel (1994)	1965-1985	Δln GDP Per capita	Log of average human capital level over time period (from Kyriacou)	Average stock	-0.079 (insignificant)	An increase of one percentage 7.9 percent decrease in GDP per capita growth
Temple(1999)	1965-1985	Log difference of output	Log of mean years of schooling	Stock	0.063 (insignificant)	An increase in the stock of human capital is associated with 6.3 percent improvement in GDP per capita growth
Pritchett (2001)	1960-1985	Rate of growth of GDP per capita	Estimation of Growth in educational capital per worker (BL(1993) data and Mincer(1974))		-0.049 (insignificant)	1% increase in the growth of education capital per worker is associated with 0.049 decreases in growth rate of GDP per labor.

Chapter 3:

Framework and Methodology

The growth equation discussed in this paper comes from an augmented neoclassical growth model. In this part, we reviewed the theoretical framework from the previous research on human capital and economic growth as discussed above. Conceptually, let us consider the study of Mankiw (Barro, Mankiw et al. 1992) as it revised the Solow's growth model through extending the capital concept to physical capital and human capital. The aggregate production function shows as follows:

$$Y(t) = K(t)^{\alpha}\, H(t)^{\beta}\, (A(t)L(t))^{1-\alpha-\beta} \quad (1)$$

Where $\alpha, \beta \in (0,1)$, $\alpha+\beta \in (0,1)$, t denotes time. The equation means that the production function shows a constant return to scales in its three factors. Y and K are output, physical capital, respectively. H is the stock of human capital and AL is productivity-augmented labor. Specifically, it is a Cobb-Douglas type production function. According to this specification, the aggregate output comes from these three factors but with different amount of proportion, where α is a share of physical capital and β is a share of human capital.

Followed the Solow model to find the equilibrium output, we transform the equation and let the equation express in per effective worked terms. This means that we divide each variable by A(t)L(t). Therefore, the number of effective workers in the economy at time t shows as follows.

$$\frac{Y(t)}{A(t)L(t)} = \frac{K(t)^{\alpha}\, H(t)^{\beta}\, (A(t)L(t))^{1-\alpha-\beta}}{A(t)L(t)} \quad (2)$$

Let $y(t)=\frac{Y(t)}{A(t)L(t)}$, $k(t)=\frac{K(t)}{A(t)L(t)}$, $h(t)=\frac{H(t)}{A(t)L(t)}$. The equation (2) hence transformed as the following:

$$y(t) = k(t)^{\alpha}\, h(t)^{\beta} \quad (3)$$

where y denotes output per capita. k denotes physical capital per capita, h is human capital per capita.

Physical capital and human capital were assumed to be accumulating factors. Thus, the dynamic equation for physical capital and human capital show as below:

$$\dot{K}(t) = s_K Y(t) - \delta K(t) \tag{4}$$

$$\dot{H}(t) = s_H Y(t) - \delta H(t) \tag{5}$$

Where s_K , s_H are the constant saving rates of physical capital and human capital, respectively. It is also noted that physical capital and human capital are assumed to depreciate at the same rate δ. Then, the equations of labor and labor-augmenting productivity (A) are:

$$\dot{L}(t) = n\ L(t) \tag{6}$$

$$\dot{A}(t) = g\ A(t) \tag{7}$$

Where n denotes population growth rate and g is technological progress rate, and both n and g are exogenously given parameters.

Therefore, the equilibrium physical capital per head $\tilde{k}^*$, human capital per head $\tilde{h}^*$, and output per head $\tilde{y}^*$ in the long-run steady state are shown as below:

$$\tilde{k}^*(t) = \left(\frac{s_k}{n+g+\delta}\right)^{\frac{1-\beta}{1-\alpha-\beta}} \left(\frac{s_h}{n+g+\delta}\right)^{\frac{\beta}{1-\alpha-\beta}} \tag{8}$$

$$\tilde{h}^*(t) = \left(\frac{s_h}{n+g+\delta}\right)^{\frac{1-\alpha}{1-\alpha-\beta}} \left(\frac{s_k}{n+g+\delta}\right)^{\frac{\alpha}{1-\alpha-\beta}} \tag{9}$$

$$\tilde{y}^*(t) = \left(\frac{s_k}{n+g+\delta}\right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\frac{s_h}{n+g+\delta}\right)^{\frac{\beta}{1-\alpha-\beta}} \tag{10}$$

With the inclusion of human capital in the model, it allows for considering the human capital effect in explaining different income levels across countries. It is anticipated that countries with more investment in education have higher income levels than countries given same investment rate in physical capital.

From the long run steady state level of output per capita in Equation (10) above, we can conclude that physical capital (k), human capital (h) and labor force(n) are three major factors in explaining economic growth in the long run. α and β correspond to shares of the physical capital and human capital.

It is worth noting that we did not explicitly include the labor force in the estimated equation in the section (3.1), as all related variables are expressed in terms of per head. The classical linear pooled regression model for cross countries data is expected to describe this steady state growth while the panel fixed effects model is used to capture and control the country-specific effect.

3.1 The estimated model in the study

By using the augmented Solow's growth model, we aim to investigate the contribution of human capital to economic growth. Three proxies to human capital are utilized to find out the best proxy.

The first model uses the share of labor force with secondary education to construct the human capital index. The definition of labor force with secondary education is the percentage of the total labor force that attained or completed secondary education as the highest level of education. This proxy is widely used by many previous growth studies. (Barro and Lee,1994; Mankiw et al.,1992). We choose the labor force with education instead of the enrollment rate because it is directly reflecting the effective supply of labor force. (Psacharopoulos and Arriagada, 1986).

Second, we use performance on the standard test measured by PISA score as an alternative measurement of human capital. Because the standardized test score is a good indicator as it's directly related to education quality, not only education quantity. (Hanushek and Ludger, 2007). In our cross-section analysis, we average three subjects (math, science and reading) to represent one country's education quality.

The third proxy is the human capital index that comes from Penn's World Table (Summers-Heston dataset). The data we used in this paper is from the latest version of Penn's World table (PWT 9.0). PWT 9.0 introduced a human capital index based on average years of schooling from Barro and Lee(Barro and Lee 2013) and it calculate the rate of return for education based on Mincer equation estimates over the world (Psacharopoulos 1994). The human capital index in PWT 9.0 is only available until the year 2014. Therefore, the time span for panel data model only includes the period 2010-2013.

To sum up, our econometric model is based on Mankiw's Growth model that extends the Solow's growth model by incorporating human capital (Mankiw, Romer, Weil,1992). The main variables are physical capital and human capital similar as augmented Solow growth model. Apart from the main variables, our model also includes dummy variable RICH to examine whether the human capital plays a different role in high income countries or upper middle income countries. The main contribution of this research is to examine the impact of human capital on economic growth. We try to distinguish the effect of human capital on economic growth. The function is written as follows.

$$yph = Af(k, hcph, rich) \tag{11}$$

Where yph is GDP per capita, A represents technological progress that is exogenously given in our model. The variable k represents the physical capital per head, variable hcph is human capital per head and rich is a dummy variable representing the upper-middle-income and high-income countries. (high-income 1, upper-middle-income 0). In the study of pooled cross-section data model, each variable is averaged from 2010 to 2016.

The estimated OLS model for cross-sectional data uses three different proxies to human capital and shown as follows:

$$\log yph_i = \alpha + \beta_1 logk_i + \beta_2 logHCPH_i + \mu_i \tag{12}$$

$$\log yph_i = \alpha + \beta_3 logk_i + \beta_4 logPISAPH_i + \mu_i \tag{13}$$

$$\log yph_i = \alpha + \beta_5 logk_i + \beta_6 logPENNPH_i + \mu_i \tag{14}$$

where:

- i denotes country
- yph is GDP per capita

- k is physical capital in terms of per head.
- RICH is a dummy variable to indicate whether the country is rich or poor.

In Equation (12), the proportion of labor force with secondary education to total labor is employed to proxy of human capital. The PISA score and the human capital index in Penn's World Table index are used to measure human capital in Equation (13) and Equation (14), respectively.

Apart from the steady state model, the study can also utilize the available data to estimate the growth model by using fixed effect estimation. The panel data estimation will also complementary help check to see the role of human capital on growth model.

In the panel model estimation, the estimated model is stated as in equations below.

$$\log yph_{it} = \alpha_i + \beta_1 logk_{it} + \beta_2 logSECph_{it} + \mu_{it} \qquad (15)$$

$$\log yph_{it} = \alpha_i + \beta_3 logk_{it} + \beta_4 logPENNph_{it} + \mu_{it} \qquad (16)$$

Where:

- i denotes country
- t denotes year
- k is physical capital in terms of per head
- SEC is a labor force with secondary education.
- PENN is a human capital index based on years of schooling and returns to education.

Equation (15) is estimated for growth if proportion of labor with secondary education to total labor was taken for human capital. Equation (16) is estimated for growth by using Penn's index as a proxy of human capital. Note that in panel data study, we didn't include the PISA standard test as a proxy of human capital, because some data are insufficient, there only have 2 years data from year 2010 to year 2013.

To examine the effect of human capital on economic growth, the appropriate estimation will be adopted in hoping to see the relationship between economic growth and human capital. The choice of econometric approach we used partially depends on the number of countries, time span and available data source. The main methodology we used in the study includes a cross-section pooled ordinary least square estimation and panel fixed effects model.

3.2 Data measurement and sources

Table 3: Data measurement and sources

Variables	**Measurement of variables**	**Data source**
Y	Average of GDP per capita constant 2010 US$	World Bank's World Development Indicator
K	Average of Gross capital formation constant 2010 US$	World Bank's World Development Indicator
HC	Average of HC (LF with sec Edu % of total	World Bank's Education Statistic. The data is available for all countries in this study except for China. The author had fulfilled the missing data by calculating from labor force with secondary education in the previous year (From Barro&Lee education attainment database) with a number of graduated populations in the following years (From CEIC China's Premium database). The detailed calculation is explained in the Appendix.
PISA	Average national PISA score of 3 subjects	OECD Programme for International Student Assessment (PISA)
PENN	Index of human capital per person, from years of schooling and	Penn's World Table 9.0, University of Groningen

	returns to education	
POP	Average population	World Bank's World Development Indicator

3.3 Human Capital Measurement based on education: China

In this research, we use the labor force with secondary education to measure human capital, however, the data is unavailable for China during some years in the study. We had to fulfill this missing data by calculating from previous data and some recently updated statistics. The calculation of this number comes from the total number of labor force with a secondary degree divided by a total number of the labor force. Total number of labor force comprises people ages 15 and above who supply to produce goods and services during a specific year. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time job seekers. (definition from labor force indicator, World Bank Database)

In order to calculate the ratio of the labor force with secondary education, we need to know the stock of the labor force in the current year to calculate the ratio in next year. We start with the ratio from Barro & Lee's Education Attainment data which is available until year 2010 as a beginning value and multiply this ratio with a total number of populations in ages 15-64 years in that year to get the stock of labor force with secondary education. To calculate the ratio in next year, we add the number of people that graduate from secondary education in that year to the stock of labor force with secondary education and divide this number by population whose age 15-64 in that years. We repeat this calculation from year 2011 until 2016 to get the complete data of the ratio of labor force with secondary education. Finally, we add all value from 2010 to 2016 and divided by a total number of years to get the average labor force with secondary education in China.

The calculation of the percentage of labor force with secondary education is written as follows:

$$SSEC_{2010} = LSEC_{2010} * LF_{2010} \tag{17}$$

$$LSEC_t = \frac{SSEC_{2010} + \sum_{i=2011}^{t} YSEC_i}{LF_t} \tag{18}$$

Where:

LSEC - Percentage of Labor force with secondary education

t - Denote for year from 2011,2012,2013,2014,2015,2016

SSEC - Stock of labor force with secondary education in 2010.

YSEC - Amount of graduated secondary education population in that year

LF - Total number of populations in labor age (15-64 years old)

CHAPTER 4:

Estimation Results and Analysis

In this chapter, firstly, we interpret the results of correlation among three human capital to see whether these measures are appropriate or not. Secondly, we interpret the results of pooled OLS model and fixed effect model to mainly examine the role of human capital in economic growth. Lastly, we summarize the results.

4.1 Results of correlation test among three human capital proxies

To check whether our measures are accurate or not, we use the correlation test. The results of correlation test for three human capital measures are presented in Table 1. As can be seen, three human capital proxies, namely, labor force with secondary education (HCPH), PISA test score (PISAPH), human capital index from Penn world table (PENNPH), are highly correlated. Specifically, all the correlated coefficients are larger than 0.97, showing strong correlation between variables. These results mean that our human capital proxies are appropriate in this study.

Table 4: The correlation matrix

Variable	PISAPH	HCPHPH	PENNPH
PISAPH	1.000		
HCPHPH	0.978	1.000	
PENNPH	0.995	0.986	1.000

4.2 Analysis of OLS regression via cross-section data

We had run 3 estimation by using ordinary least squares method. Given that heteroskedasticity issue is important in cross country study, the standard errors are adjusted by white heteroskedasticity-consistent covariance matrix. The sample includes 57 observations during the period 2010 -2016. The result for Equation (12), (13), and (14) are presented in following equation:

Regression result of model with labor force with secondary education as a proxy of human capital

$\widehat{lnyph_i}$ = 1.941+ 1.012lnk_i + 0.0043ln$HCPH_i$ (19)

($\widehat{\beta *}$) (0.955) (0.089)

(T-statistic) (5.17) (29.23) (2.72)

Adjusted R-squared=0.941; SSR=2.463; F-statistic=451.34; DW=1.708

Regression result of the model with the PISA Score as a proxy of human capital

$\widehat{lnyph_\iota}$ = 1.863 + 1.01lnk_i + 0.044ln$PISAPH_i$ (20)

($\hat{\beta}$ *) (0.953) (0.087)

(T-statistic) (5.15) (28.98) (2.65)

Adjusted R-squared=0.943; SSR=2.479; F-statistic=448.12; DW=1.687

Regression result of the model with Penn's World Index as a proxy of human capital

$\widehat{lnyph_\iota}$ = 2.374 + 0.982lnk_i + 0.046ln$PENNPH_i$ (21)

($\widehat{\beta *}$) (0.949) (0.094)

(T-statistic) (5.81) (29.50) (2.94)

Adjusted R-squared=0.94; SSR=1.919; F-statistic=482.88; DW=1.90

Remark: ($\widehat{\beta *}$) is standardized coefficient

As can be seen in the estimated result, physical capital plays an important role in promoting economic growth as the variable k is statistically significant at the 1% level in all equations, which is consistent with the traditional Solow model. This finding suggests that physical capital is the main driving force of economic growth. Comparing with human capital, the effect of physical capital is greater as it has a relatively higher coefficient value. The value of the standardized coefficient in physical capital is around 0.95(in equation 19,20 and 21), Which means that with one percentage increase in physical capital per capita, the growth of GDP per capita will increase 0.95 percentage. Our result is consistent with the classic growth model in which physical capital is positively associated with better economic growth performance. According to the Solow's growth model, physical capital is one of the main factors to produce output for a nation. The economy can grow via factor accumulation. More physical capital will allow each labor force has more tools to produce and thus lead to more output.

As we expected, human capital is another influential factor in determining economic growth in the model. Since all human capital proxies show positive and statistically significant result, implying that human capital has a positive effect on economic growth. Hence, the inclusion of human capital accumulation could increase the impact of physical capital accumulation on the steady-state level of output. This finding is consistent with Mankiw, Romer, Weil (1992) as well as Barro and Lee (1994), who also found that human capital is associated with a higher level of GDP per capita.

Comparing to all proxies of human capital in cross-section studies, human capital provided by Penn World Index provides the relatively best result since the t-statistic is 2.94 and the variable LPENN is statistically significant at the 1 percent level. The PISA score and the labor force with secondary education are both statistically significant but with lower significance.

4.3 Analysis of country heterogeneity of marginal effect of human capital

In this section, we add the interaction term “RICH*LHCPH” into the model to examine whether the effect of human capital in upper middle income and high income countries are different or not. The variable RICH is used to indicate whether the country is high or upper-middle income countries.

Result of OLS regression by adding interaction term (labor force with secondary education)

$$\widehat{lnyph_i} = 2.826 + 0.889\ln k_i + 0.045\ln HCPH_i - 0.216RICH_i - 0.04RICH_i * \ln HCPH_i \quad (22)$$

$(\widehat{\beta *})$ (0.838) (0.092) (-0.119) (-0.272)

(T-statistic) (6.536) (18.135) (2.046) (-0.543) (-1.321)

Adjusted R-squared=0.952; SSR=1.965; F-statistic=275.68; DW=1.88

Result of OLS regression by adding interaction term (PISA test score)

$$\widehat{lnyph_i} = 2.728 + 0.888\ln k_i + 0.046\ln PISAPH_i - 0.059RICH_i - 0.034RICH_i * \ln PISAPH_i \quad (23)$$

$(\widehat{\beta *})$ (0.838) (0.089) (-0.032) (-0.187)

(T-statistic) (6.44) (18.02) (1.785) (-0.165) (-1.034)

Adjusted R-squared=0.950; SSR=1.991; F-statistic=271.85; DW=1.87

Result of OLS regression by adding interaction term (Penn World Table Human Capital Index)

$$\widehat{lnyph_i} = 3.259 + 0.888\ln k_i + 0.061\ln PENNPH_i - 0.546RICH_i - 0.05RICH_i * \ln PENNPH_i \quad (24)$$

$(\widehat{\beta *})$ (0.858) (0.124) (-0.306) (-0.423)

(T-statistic) (6.477) (19.889) (2.312) (-1.044) (-1.553)

Adjusted R-squared=0.956; SSR=1.538; F-statistic=292.53; DW=2.1

The results show it is consistent with the basic model, which means all human capital proxies enters significantly in growth model. However, the estimated results show that the effect of human capital are not statistically significant different between these two income groups, with the P-value of all human capital proxies are insignificant at conventional levels. This means that in our growth model, we cannot distinguish the role of human capital between high income countries and upper middle income countries. We can also interpret these results to that there is no significant difference about the effect of human capital in economic growth in high-income countries and upper-middle income countries.

Since the interaction term results show that the impact of human capital in high income and upper middle income countries are not distinguishable, therefore, in order to know whether the economic growth depend on the country's income level or not, we add the dummy variable "RICH"(to indicate whether the country are upper middle or high income countries) into the model to investigate the relationship between economic growth and country's income level. The results show as bellow.

Result of OLS regression by adding dummy variable (labor force with secondary education)

$$\widehat{lnyph_i} = 2.578 + 0.885 lnk_i + 0.024 lnHCPH_i + 0.298 RICH_i \quad (25)$$

$(\widehat{\beta *})$ (0.835) (0.05) (0.164)

(T-statistic) (6.57) (17.96) (1.563) (3.357)

Adjusted R-squared=0.953; SSR=2.03; F-statistic=361.89; DW=1.92

Result of OLS regression by adding dummy variable (PISA test score)

$\widehat{lnyph_i}$ = 2.548+ 0.883lnk$_i$ + 0.025lnPISAPH$_i$ + 0.301RICH$_i$ (26)

$(\widehat{\beta *})$ (0.832) (0.049) (0.166)

(T-statistic) (6.592) (18.00) (1.55) (3.416)

Adjusted R-squared=0.95; SSR=2.03; F-statistic=361.64; DW=1.909

Result of OLS regression by adding dummy variable (Penn World Table Human Capital Index)

$\widehat{lnyph_i}$ = 2.775+ 0.881lnk$_i$ + 0.0281lnPENNPH$_i$ + 0.256RICH$_i$ (27)

$(\widehat{\beta *})$ (0.851) (0.057) (0.143)

(T-statistic) (6.93) (19.56) (1.768) (3.077)

Adjusted R-squared=0.955; SSR=1.614; F-statistic=378.54; DW=2.1

As can be seen in the estimated result, physical capital still is an influential factor in promoting economic growth as the variable k is statistically significant at the 1% level in all equations (equation 25,26,27). In addition, the estimated results show that dummy variable "RICH" is another important factor in economic growth as the variable " RICH" is statistically significant at the 1% level, which mean the difference of economic growth only expressed in intercept term, this mean the growth of these two income countries are difference because of being upper middle or high income countries. Comparing with our previous cross-term model, we found that in interaction model, all coefficient of cross-term is insignificant, which mean there is no difference in structure of growth due to different groups of countries. Furthermore, human capital is an third influencing factor found in this model since all coefficients of human capital show positively and statistically significant. And the results also show that the human capital provided by Penn World Index provide the little better result since it is most significant at the 10 percent level.

4.5 Analysis of panel fixed effect model

Apart from the steady state growth model above, the study also utilized the data set to estimate the growth model by using panel fixed effects estimation in hoping to compare the role of human capital by using the different indicators discussed earlier. Panel data model can offer more strong tests and credible estimates as it collects the information from cross-section data and controls the time-invariant country-specific effect. The detail is as follows.

We had run 2 estimation by using panel fixed effects method and two different proxies for human capital. Note that in panel data study, we exclude the PISA standard test due to that PISA test is conducted every 3 year and thus there are only one year data available from 2010 to 2013 in most of countries. The sample includes 46 countries for the time period 2010-2013 with totally 184 observations. The first regression uses the labor force with secondary education as a proxy to human capital. The second regression use Penn's World index to measure human capital proxy. The results for each model are presented as following equations:

Regression result of fixed effect model using labor force with secondary education as a proxy of human capital

$$\widehat{lnyph_{it}} = 7.300 + 0.296lnk_{it} - 0.018lnHCPH_{it} \quad (28)$$

(T-statistic) (20.74) (12.43) (-0.68)

F-statistic=2981.7; DW=1.2

Regression result of fixed effect model using Penn's World human capital index as a proxy of human capital

$$\widehat{lnyph_{it}} = 16.403 + 0.305lnk_{it} + 0.593lnPENNPH_{it} \quad (29)$$

(T-statistic) (5.39) (13.45) (2.93)

F-statistic=3159.7; DW=1.2

According to our estimation results of the panel fixed effect model, human capital measured by labor force with secondary education shows an unexpected sign and become insignificant. This result is inconsistent with many previous literatures that find a significant positive relationship between years of schooling and economic growth.

In addition, another proxy of human capital measured by Penn's World Index shows a positive and significant impact on economic growth, which is consistent with the neo-classical growth theory. By adopting country specific factor, the model indicates that human capital is the most influencing factor to growth with the coefficient value 0.59. The physical capital comes the second. According to our estimated results, it shows that physical capital is still an important factor to determine economic growth with higher coefficient value 0.30 and it is statistically significant at 1 the percent level. Therefore, we can conclude that the growth model that incorporating country specific effect is performing better than the long term growth model. Human capital index come from Penn World Table that incorporated with qualitative aspect of human capital is the best proxy of human capital.

For the steady state growth model, it requires equilibrium condition in the steady state while the range of our dataset cannot ensure long run equilibrium for all countries in the sample. However, for the fixed effect panel data estimation, the specific country effect can pick up all different specific factors. As a consequence, inclusion of the human capital in to the model can show precise result. Hence, by qualitative aspect of human capital of the human capital index taken from Penn World Table can be found as the best proxy of human capital compared to human capital index derived from education attainment alone.

There may also be two reasons accounting for the weak relationship between years of schooling and economic growth in our study. First, solely education attainment may ignore some other factors that may also affect human capital formation. For example, the differences in the institutional framework (Pritchett 2001) and education quality are also important in generating human capital. The considerable cross-country differences in education quality is a major drawback in such quantitative measurement (Hanushek and Wößmann 2007). Second, the countries with small size (perhaps a few unrepresentative countries) in which human capital accumulation has slight or even little effect on economic growth and this may cause a considerable impact on the overall estimation (Benhabib and Spiegel 1994).

CHAPTER 5:

Conclusion

This research reexamined the influence of human capital on economic growth by using three different proxies of human capital, namely labor force with secondary education, PISA standard test and Penn's World Table with the human capital index. We include physical capital as control variable in the model. In addition, we add one dummy variable RICH in the model to indicate country's income level, high income and upper-middle income country, respectively. For methodology, we applied cross-section model and panel fixed effect model to estimate the relationship of each variable to economic growth.

In the cross country analysis, we average data of each variable from data points of every year for all 57 countries. The result shows that human capital is one of the crucial factors for economic growth in long run steady state equilibrium condition. Furthermore, we also include interaction term to test whether the role of human capitals are different in high income and upper middle income countries. For the panel data analysis, there are 46 countries from year 2010 to 2013 and only 2 proxies of human capital are included. The advantage of fixed effect model is that it captures and controls the different country-specific effect.

According to empirical results from cross-section ordinary least square model and panel fixed effects model, we found that these two models show consistent results. That is, human capital has significant positive relation to economic growth. However, the growth model that captures country specific effect performing better than the long term steady state growth model. The interaction term included is found statistically insignificant with all human capital proxies, which implies no different marginal effect of the role of human capital in explaining economic development between upper middle income countries and high income countries. Meanwhile, we found that the growth difference only represents in intercept term, this mean the growth of these two income countries are different in average effect; there is no difference in structure of growth due to different groups of countries.

This study uses three proxies of human capital. All the test results show that human capital as measured by Penn's World human capital index provides little better results with highest significance level compared to the other human capital proxies. The possible explanation is that the Penn's World Table is an index of human capital per person, based on years of schooling and returns of education and it combines all components of the labor force that can influence labor productivity. It may reflect into account more details of productivity improvement of the labor force than other two indices. The secondary education may not be a direct measurement of human capital across different countries. The Penn's World Index not only considers years of schooling, but it also includes a return to education based on the quality of education which is different among each country. Therefore, it can accurately represent human capital in each country.

For another two human capital proxies, we found that compared with solely years of schooling, PISA standard test is a better indicator. The possible explanation is that the PISA test is conducted with the same standard around the world while the years of schooling may have different standards across many countries. While PISA score reflects better in labor productivity, sometime the score may not fully capture the actual productivity improvement. Therefore, we can conclude that Penn's World Table gives the best answer to the role of human capital in economic growth in both analysis of cross section and panel data in our study.

APPENDIX

Appendix 1: Definition of variables

Variables	Definitions
Y (GDP per capita, constant 2010 US $)	Calculation of GDP per capita is based on PPP or purchasing power parity. Gross domestic product purchasing power parity rates in international dollar had been converted to PPP GDP. The GDP of Buyer's price is the accumulation of total volume of all local producer in the country including any product taxes and exclude any subsidies excluded in the product's value. The calculation hadn't used any deduction for depreciation rate of physical assets and not accounted for degradation and depletion of natural resources. The unit is calculated as constant of year 2011 international dollars.
K (Gross capital formation constant 2010 US $)	Also known as gross domestic investment gross capital contains an amount on additions to the fixed assets of the economy with total changes in the level of inventories. It also includes hospital, offices, schools and private residential and industrial buildings and permanents asset such as area development, plantation, industry machine, equipment purchasing and road-building, train and railways. Accounts are stocks of products held by firms to meet temporary or unexpected fluctuations in production or sales or developing. From the SNA, total acquisitions of value are also considered. The unit is calculated as constant of year 2011 international dollars.
HC(LF with sec edu,% of total)	Percentage Labor force with secondary education is the percentage of the total labor force that completed or take part in secondary education as the highest level of education. The unit is in percentage of total labor force.

PISA - Math score	Average cognitive skill on the mathematics subject. The mean score of fifteen years old students on the mathematics examination. The metric represents overall mathematic skill ranked by all countries that take part in the exam. The average score of the result is 500 with a 100 score of SD. This is a measurement of country overall performance in the year that the exam had taken part which means the score may not be comparable across countries and years.
PISA – Reading score	Average cognitive skill on the reading subject. Average score of of fifteen years old students on the reading examination. The metric represents overall reading skill ranked by all countries that take part in the exam. The average score of the result is 500 with a 100 score of SD. This is a measurement of country overall performance in the year that the exam had taken part which means the score may not be comparable across countries and years.
PISA - Science score	Average cognitive skill on the science subject. Average score of of fifteen years old students on the science examination. In PISA 2006 the mean science score for OECD countries was initially set at 500 points (for 30 OECD countries), then was re-scaled to 498 points after included new OECD countries. This is a measurement of country overall performance in the year that the exam had taken part which means the score may not be comparable across countries and years.
average of three subject	Average of 3 PISA score in each year

Appendix 2: List of countries in samples

Country ID	Country	Income level	Cross Sectional Data	Panel Data
1	Australia	high-income	*	*
2	Austria	high-income	*	N/A
3	Belgium	high-income	*	*
4	Chile	high-income	*	*
5	Canada	high-income	*	N/A
6	Cyprus	high-income	*	*
7	Czech Republic	high-income	*	*
8	Denmark	high-income	*	*
9	Estonia	high-income	*	*
10	France	high-income	*	*
11	Finland	high-income	*	*
12	Germany	high-income	*	*
13	Greece	high-income	*	*
14	Hong Kong SAR, China	high-income	*	*
15	Hungary	high-income	*	*
16	Iceland	high-income	*	*
17	Ireland	high-income	*	*

18	Italy	high-income	*	*
19	Latvia	high-income	*	*
20	Luxembourg	high-income	*	*
21	Lithuania	high-income	*	*
22	Macao SAR, China	high-income	*	*
23	Malta	high-income	*	*
24	Netherlands	high-income	*	*
25	Norway	high-income	*	*
26	Poland	high-income	*	*
27	Portugal	high-income	*	*
28	Singapore	high-income	*	*
29	Slovak Republic	high-income	*	*
30	Slovenia	high-income	*	*
31	Spain	high-income	*	*
32	Sweden	high-income	*	*
33	Switzerland	high-income	*	*
34	United Kingdom	high-income	*	*
35	United States	high-income	*	*
36	Uruguay	high-income	*	*
37	Argentina	upper-middle	*	*

38	Brazil	upper-middle	*	N/A
39	Bulgaria	upper-middle	*	*
40	China	upper-middle	*	*
41	Colombia	upper-middle	*	*
42	Costa Rica	upper-middle	*	N/A
43	Croatia	upper-middle	*	*
44	Kazakhstan	upper-middle	*	*
45	Macedonia, FYR	upper-middle	*	N/A
46	Malaysia	upper-middle	*	*
47	Mexico	upper-middle	*	N/A
48	Montenegro	upper-middle	*	N/A
49	Peru	upper-middle	*	N/A
50	Romania	upper-middle	*	*
51	Russian Federation	upper-middle	*	*
52	Serbia	upper-middle	*	*
53	Thailand	upper-middle	*	*
54	Turkey	upper-middle	*	*
55	Albania	upper-middle	*	N/A
56	Algeria	upper-middle	*	N/A
57	Dominican	upper-middle	*	N/A

The data come from world bank national account data. According to the thresholds for classification by income are:

- Upper-middle income(3896-12,005, GNI/Capita)

- High-income(>12,055 GNI/Capita)

Appendix 3: Mean and standard deviation of variable

	57-country sample (cross-country)		46-country sample (panel data)	
Variable	Mean	σ	Mean	σ
Log yph	9.88	0.882	10.055	0.811
Log k	8.38	0.833	8.523	0.776
Log hcph	-12.485	1.818	-12.445	1.808
Log Penn PH	-15.003	1.731	-15.095	1.747
Log Pisa PH	-10.11	1.735		
Rich (dummy)	0.632	0.487	0.739	0.44

REFERENCES

Au, A. K. M., Y. Altman and J. J. J. o. E. I. T. Roussel (2008). "Employee training needs and perceived value of training in the Pearl River Delta of China: A human capital development approach." **32**(1): 19-31.

Barro, R. J. (1996). Determinants of economic growth: a cross-country empirical study, National Bureau of Economic Research.

Barro, R. J. and J.-W. J. J. o. m. e. Lee (1993). "International comparisons of educational attainment." **32**(3): 363-394.

Barro, R. J. and J. W. J. J. o. d. e. Lee (2013). "A new data set of educational attainment in the world, 1950–2010." **104**: 184-198.

Barro, R. J. and J. W. J. T. A. E. R. Lee (1996). "International measures of schooling years and schooling quality." **86**(2): 218-223.

Barro, R. J., N. G. Mankiw and X. Sala-i-Martin (1992). Capital mobility in neoclassical models of growth, National Bureau of Economic Research.

Barro, R. J. J. T. q. j. o. e. (1991). "Economic growth in a cross section of countries." **106**(2): 407-443.

Bassanini, A. and S. Scarpetta (2001). "Does human capital matter for growth in OECD countries? Evidence from pooled mean-group estimates."

Beach, J. M. J. E. S. (2009). "A critique of human capital formation in the US and the economic returns to sub-baccalaureate credentials." **45**(1): 24-38.

Becker, G. S. J. C., New York (1964). "Human capital theory." **1964**.

Benhabib, J. and M. M. J. J. o. M. e. Spiegel (1994). "The role of human capital in economic development evidence from aggregate cross-country data." **34**(2): 143-173.

Brian, K. (2007). <u>OECD Insights Human Capital How what you know shapes your life: How what you know shapes your life</u>, OECD publishing.

Card, D. and A. B. J. J. o. p. E. Krueger (1992). "Does school quality matter? Returns to education and the characteristics of public schools in the United States." **100**(1): 1-40.

Caselli, F., G. Esquivel and F. J. J. o. e. g. Lefort (1996). "Reopening the convergence debate: a new look at cross-country growth empirics." **1**(3): 363-389.

Chang, X. and Y. J. P. C. S. Shi (2016). "The Econometric Study on Effects of Chinese Economic Growth of Human Capital." **91**: 1096-1105.

Chen, D. H. and C. J. Dahlman (2004). Knowledge and development: a cross-section approach, The World Bank.

Cohen, D. and L. Leker (2014). "Health and education: Another look with the proper data."

Cohen, D. and M. J. J. o. e. g. Soto (2007). "Growth and human capital: good data, good results." **12**(1): 51-76.

Ding, S., J. J. O. B. o. E. Knight and Statistics (2011). "Why has China grown so fast? The role of physical and human capital formation." **73**(2): 141-174.

Feenstra, R. C., R. Inklaar and M. P. J. T. N. G. o. t. P. W. T. Timmer, available for download at www. ggdc. net/pwt (2013). "Penn world table version 8.0."

Fleisher, B., H. Li and M. Q. J. J. o. d. e. Zhao (2010). "Human capital, economic growth, and regional inequality in China." **92**(2): 215-231.

Hanushek, E. A. and D. D. J. A. e. r. Kimko (2000). "Schooling, labor-force quality, and the growth of nations." **90**(5): 1184-1208.

Hanushek, E. A. and L. Wößmann (2007). The role of education quality for economic growth, The World Bank.

Harbison, F. H. and C. A. Myers (1964). Education, manpower, and economic growth: Strategies of human resource development, Tata McGraw-Hill Education.

Kaneko, M. J. E. and T. W. B. Training Department, Washington DC (1986). "The educational composition of the world population: A database, Report EDT 29."

Kraipornsak, P. (2009). "Roles of human capital and total factor productivity growth as sources of growth: Empirical investigation in Thailand." International Business Economics Research Journal **8**(12): 37-52.

Kwon, D.-B. (2009). Human capital and its measurement. The 3rd OECD World Forum on “Statistics, Knowledge and Policy” Charting Progress, Building Visions, Improving Life.

Lau, L., D. Jamison and L. J. P. W. B. Louat (1991). "Impact of education by region."

Lee, J. W. and R. J. J. E. Barro (2001). "Schooling quality in a cross–section of countries." **68**(272): 465-488.

Levine, R. and D. J. T. A. e. r. Renelt (1992). "A sensitivity analysis of cross-country growth regressions." 942-963.

Mankiw, N. G., D. Romer and D. N. J. T. q. j. o. e. Weil (1992). "A contribution to the empirics of economic growth." **107**(2): 407-437.

Mincer, J. (1974). "Schooling, Experience, and Earnings. Human Behavior & Social Institutions No. 2."

Murphy, K. M., A. Shleifer and R. W. J. T. q. j. o. e. Vishny (1991). "The allocation of talent: Implications for growth." **106**(2): 503-530.

Nehru, V., E. Swanson and A. J. J. o. d. E. Dubey (1995). "A new database on human capital stock in developing and industrial countries: Sources, methodology, and results." **46**(2): 379-401.

O'sullivan, A. and S. M. Sheffrin (2003). "Economics: Principles in action."

Pritchett, L. J. T. w. b. e. r. (2001). "Where has all the education gone?" **15**(3): 367-391.

Psacharopoulos, G. and A. M. J. I. l. L. R. Arriagada (1986). "The educational composition of the labour force: an international comparison." **125**: 561.

Psacharopoulos, G. J. W. d. (1994). "Returns to investment in education: A global update." **22**(9): 1325-1343.

Romer, P. M. J. J. o. E. p. (1994). "The origins of endogenous growth." **8**(1): 3-22.

Schultz, T. W. J. T. A. e. r. (1961). "Investment in human capital." **51**(1): 1-17.

Solow, R. M. J. T. q. j. o. e. (1956). "A contribution to the theory of economic growth." **70**(1): 65-94.

Summers, R., A. J. R. o. i. Heston and wealth (1988). "A new set of international comparisons of real product and price levels estimates for 130 countries, 1950–1985." **34**(1): 1-25.

Wang, Y. and Y. Yao (1999). <u>Sources of China's economic growth, 1952–99: incorporating human capital accumulation</u>, The World Bank.

Wei, C. J. C. E. R. (2008). "The role of human capital in China's economic development: Review and new evidence." **19**(3): 421-436.

Whalley, J. and X. J. C. E. P. R. Zhao (2013). "The contribution of human capital to China's economic growth." **2**(01): 1350001.

Zhang, C. and L. J. C. E. R. Zhuang (2011). "The composition of human capital and economic growth: Evidence from China using dynamic panel data analysis." **22**(1): 165-171.

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