SENIOR RESEARCH

Topic: Effects of Universal Health Coverage and Health Measures on Economic Growth–
The Case of ASEAN Countries

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Date: May 2, 2015

Senior Research Submitted in Partial Fulfillment of the Requirements

for the Bachelor of Arts degree in Economics (International Program)

The Bachelor of Arts Program in Economics

Faculty of Economics

Chulalongkorn University

Academic year 2014

Approve

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Date of Approval __________________________

Abstract

The purpose of this paper is to evaluate the effects of health status of population, along with the implementation of Universal Health Coverage (UHC), on economic growth for ASEAN countries from the year 1990-2010. This paper departs from other studies in that it combines several health proxies together to measure the direct impact from each proxy and examines the role that UHC play on economic growth, as measured by Gross Domestic Product (GDP). Panel data is analyzed using fixed effects model, controlling for the country-specific sources of bias. Results show that only life expectancy and average of adult survival rate (ASRA) positively affect GDP with statistically significant coefficients. Mortality rates for both under-5 and infants show a reverse correlation, though having insignificant coefficients. UHC, however, plays no role in any of the models, by showing no sign of significance. Improvements in health are then confirmed to be an important tool for countries to raise overall output in the long run, as well as sustaining growth and well-being of the population.

Contents

I. Introduction

Talking about Solow-Swan's growth model, we all know that its main assumption is that output is produced according to the production function in an aggregate level. If, however, the production function takes Cobb-Douglas form, the well-known model of $Y_{it} = A_{it}K_{it}^{\alpha}L_{it}^{1-\alpha}$ will be formed; where Y represents output, A represents technological progress, K represents physical capital, and L represents labor, respectively (subscript it represents different entities across periods of time). From the production function, it can be understood that physical capital and labor are the two main factors that drive output, or for simplicity, economic growth. Nevertheless, it won't make sense, practically, to say that only two factors impact economic growth. Any factors that can add productivity to labor or capital must also be accounted for. In this case, it is more reasonable to include health in the production function as well.

One significant contribution of health to economic growth is that health directly increases labor's productivity. In simpler words, better health generally leads to longer life span and longer life span typically means an increase in labor's productivity, ceteris paribus. Starting off with micro-level explanation, Keas Employee Happiness Index, where Keas is a market leader in enterprise health management, shows that employees who participate in health programs are three times more likely to be engaged and satisfied in their work (Woody, 2013). Josh Stevens, Keas' CEO, also pointed out that it is important to link health, happiness, and productivity together since career engagement which leads to better productivity is a function of both intrinsic factors such as health and extrinsic factors such as bonus compensation. Bloom, Canning, and Sevilla (2003), providing macro-level explanation, believed that healthier employers are more productive and less likely to be absent from work. In an aggregate level, better health could lead to an increase in overall productivity; therefore, health must also be accounted as one of the factors that drive economic growth.

Bhargava, Jamison, Lau, and Murray (2001) pointed out that health statuses as measured by Adult Survival Rate (ASR) can impact countries in different ways depending on the estimates Gross National Income (GNI) per capita or the classifications of economy each country is in. For example, there seem to be large positive effects of improved health on GDP growth rates for developing countries (low-income countries) such as Burkina Faso, Burundi, and Central African Republic. In highly developed countries (high-income countries) such as USA, France, and Switzerland, however, the effects were negative. The use of different health measures could also yield different results which mean that the effects are subject to change depending on which health proxies were being used. Bloom et al. (2004) estimated the effects of improvement in 1-year life expectancy on output and found a 4% contribution, consequently. Bhargava et al. (2001), nonetheless, estimated the effects of a 1% change in ASR on growth rate and found a corresponding 0.05% increase (note that different independent variables were being controlled in each model). The disparities between results in each model might happen because several variables were not similar across models and that each health proxy which served as explanatory variables explained health statuses in different ways.

Not only reviewed literatures that show significant contribution of health to economic growth, the blueprint agreed to by all the world's countries which was set up following the Millennium Summit of the United Nations in 2000, the Millennium Development Goals (MDG) also emphasizes the significance of having "good" health across nations . MDG's goals are as followed: (1) reducing poverty (2) achieving universal primary education (3) endorsing gender equality (4) lowering child mortality rates (5) improving maternal health (6) decreasing infectious disease's prevalence (7) promoting environmental sustainability and (8) developing a global partnership for development (United Nations Development Programme, 2001). Three of the goals aim to tackle health issues which show that health should be included as another important determinant of countries' economic growth.

The purpose of this research paper is to explore the relationship (and/or causality) between explanatory variables that explain health status of countries' population and the conditions of countries' economies measured by the value of Gross Domestic Product (GDP), as well as measuring the effects of implementing Universal Health Coverage (UHC) whether its impacts are large, small, or negligible. Though health status can be observed at households or micro-level, this research does focus on aggregate data or macroeconomics level. One reason is that it is more vivid and comprehensive to look at the effects in the big picture, along with the accessibility to macroeconomic data. In macro-level, it is important to specify the countries in which the effects should be observed or else huge complications can arise from misspecifications. I'll only focus on ASEAN countries which include Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam across 21-year period from 1990-2010.

UHC has become the focus of our research since literatures previously studied haven't distinctly covered the effects of UHC implementation on economic growth. UHC, according to its definition by World Health Organization (2014), is the "critical component of sustainable development and poverty reduction and also a key element of any effort to reduce social inequities". UHC helps citizens in which it provides (almost) 100% of its citizens, as the name "universal" suggests, with basic health needs through an affordable and accessible system. It makes sure that citizens can meet their health demands without suffering financial hardship. UHC is one way that government uses to improve the well-being of all citizens. The implementation of UHC, however, needs a thorough cost-benefit analysis since huge cost will be borne by the government and involving parties. As a result, though UHC seems to be very important in ensuring well-being of citizens, not every country chooses to implement it due to specific-country reasons and/or the cost burden. Implementing UHC might then impact economic growth that its effects can be huge, meager, or negligible.

As mentioned earlier, the purpose of this paper is to explore the relationship between health and economic growth. Health statuses, in this paper, will be approximated using diverse measures based on the available data along with their corresponding relevance since no definite measures are confirmed to be the best. The measures include both health outcomes which examine health output and health inputs which only assess the predetermined condition of health statuses. The effects, controlled for the same independent variables, will then be analyzed to see which measures are reliable. UHC will also be added later on to examine its roles on economic growth.

II. Literature Review

Several literatures regarding the effects of health on economic growth have been reviewed. Almost all of the literature ended up in similar conclusion that health impacts the economies in one or the other ways. Many literatures have been studied in order to provide me as the most comprehensive concept of this topic. Note that not every model, independent variable, or explanatory variable is provided or explained in the papers being discussed below in order to reduce potential complications.

Weil (2006) used the equation $\ln(y_i) = \frac{1}{1-\propto}\ln(A_i) + \frac{\propto}{1-\propto}\ln\left(\frac{k_i}{y_i}\right) + \ln(h_i) + \ln(v_i)$; where y represents GDP per worker, A represents country-specific productivity terms, $\frac{k}{y}$ represents capital per output ratio, h represents human capital in the form of education, v represents human capital in the form of health (subscript i represents country indexes) in his paper *Accounting for the Effects of Health* *on Economic Growth* to analyze the extent in which health differences could explain income differences between countries from different income level classifications and calculated the gains in income resulting from the improvements made in health. He started off using average height of adult men as health proxy, since height could be another measures reflecting the health environment in which each person has grown up. He proposed that malnutrition and/or the prevalence of severe diseases are highly correlated with diminishing heights. The second proxy used was again ASR for men, which seem to be the baseline for running the model. The third proxy used here was the age of menarche, or the age of first menstruation. Generally, his studies show that girls in wealthier countries reach menstruation earlier than those in poorer countries. Weil, however, didn't specify which exact countries or regions were being used as his samples since data were available differently in each region so each health proxy was analyzed under unequal numbers of observations, accordingly.

From the available data, using ASR as health proxy, the results show that eliminating health gaps across nations reduced the variance of log GDP per worker by 9.9%. Changing the proxy to age of menarche didn't significantly change the results, though health playing a slightly larger role. Weil also explained his results using direct effects that health would have on economic growth by saying that intuitively, the healthier the worker, the better the productivity, and also the higher the output. Nevertheless, indirect channels through which health can impact economic growth such as through the capital accumulation of both physical and human capital haven't yet been analyzed.

Similar conclusions have also been reached by Knowles and Owen (1997) in *Education and Health in an Effective-Labour Empirical Growth Model.* Instead of treating both health and education as separate factors of production, the authors treated them as labor-augmenting. The equation $\bar{L}_{it} = A_{it}E_{it}^{\theta_1}X_{it}^{\theta_2}L_{it}$ was used to incorporate education and health as labor-augmenting where $\bar{L}$ represents the 'effective-labor' variable, L represents raw labor input, A represents level of technology, E represents educational status, and H represents health status, respectively. Cross-sectional data from 77 countries was used with average years of schooling as education proxy and life expectancy at birth as health proxy. By using several methods to estimate the effects, in which dependent variable is the log difference of real GDP per working-age person, results show that health was statistically significant to output per worker as well as economic growth. Education, however, wasn't that statistically significant throughout different models. Knowles and Owen also provided insightful explanation regarding the impacts of health on economic growth–improvements in health status increased worker's productivity by lowering absenteeism, morbidity, and mortality rates. Additionally, health improvements such as an increase in life expectancy incentivized the acquisition of human capital like returns to schooling in which the returns are larger over time.

Bhargava, Jamison, Lau, and Murray (2001) examined the effects of ASR on GDP growth rate on 5-year intervals for 92 countries in *Modeling the Effects of Health on Economic Growth*. In this paper, though similar conclusions were drawn, different approaches were used. The authors used information on countries' income level classifications to approximate different economic growth rate corresponding to each level of income classification. Important independent variables used here include the proportion of areas in the tropics, total fertility rate (the ratio of live births in an area to the population of that area), and investment/GDP ratio. Health was measured using ASR from many countries. Using static random effects model with real GDP per capita growth rates as dependent variable, results show that the effects were more statistically significant for low-income countries. A 1% change in ASR constituted to around 0.5% increase in growth rates for very poor countries. The effects of ASR in developing countries' sample like Burkina Faso, Burundi, and Central African Republic on growth rate were significantly positive. On the contrary, results were reversed for developed countries like USA, France, and Switzerland. Bhargava et al. (2001) also stated that health measure such as ASR might capture different information given countries' income classifications. In developing countries, ASR was likely to reflect the level of nutrition, smoking prevalence rates, infectious diseases prevalence, etc. For developed countries, however, genetic factors and costs of curative health care were reflected through the differences in ASR. As a result, since time interval was clearly set, negative effects might result from the slow growth rates with correspondingly high ASR in the sample periods for developed countries; therefore, it would be better to include additional health measures for more complete information.

A more thorough research, *When Does Improving Health Raise GDP?,* was done in 2008 by Ashraf, Lester, and Weil. Weil, as mentioned above, and his colleagues extended his previous research to explore the indirect effects of health on economic growth as well as the direct ones. In the paper, the authors took the population growth and structural change effects into account, along with the capital accumulation effects of health and crowding out of resources effects. Moreover, different health measures were used here. The effects on economic growth were explored by the increase in life expectancy, which measured the average health status of nation's population, and the eradication of diseases like malaria and tuberculosis. Using simulation models, results show that increasing life expectancy from 40 to 60 would increase GDP per capita by 15% in the long run and approximately 2% would result from eradicating malaria and/or tuberculosis in sub-Saharan Africa. Findings also revealed that it would take a really long time, longer than a decade, for the effects to take place. Interestingly, the gains that would result from improvements in health might be offset by the growth in population over time. The authors then suggested policymakers that modern birth control methods should be available to limit the number of population so that the population growth effects wouldn't cancel out the increase in income effects. In addition, suggestions about educational institutions such as the sufficient number of teachers and schooling activities to support the growing number of school-age children were also made. Though the lags seem long and negative effects on income might prevail due to long lags, improvements made in health were still prominent in increasing the well-being of societies, maybe not economically, but humanitarianly.

Swift (2011) also assessed the long-term endogenous relationship between health and GDP and GDP per capita, as well as, measuring whether the effects would be constant over time or not in *The Relationship Between Health and GDP in OECD Countries in the Very Long Run*. The observations were made over two periods between 1820-2001 and 1921-2001 for 13 OECD (Organization for Economic Cooperation and Development) countries. Given very long periods, only data on life expectancy was available to be used as health measure. Though life expectancy couldn't capture every improvement made in health, for example, improvement in nutrition might add to worker's productivity but not necessarily life span, it was the only available and usable health measure for the model. Using vector error correction model (VECM) for Johansen multivariate cointegration method for long-run relationship, results show that a 1% increase in life expectancy corresponded to an average increase of 6.124% across 13 countries. Among all the countries, only Finland's and Spain's coefficients were not significant; this in turn indicated that there was a positively significant effect of life expectancy on GDP. By changing the variable GDP to GDP per capita, the results were similar except that the average increase was around 4.995%. However, under short-run relationships, the results were contrasting. An increase (or decrease) in life expectancy didn't seem to statistically affect both GDP and GDP per capita over short-run periods. Short-run coefficients were small and negative, except those in France, which implied the consequence of the effects of population growth that would happen as a result of health improvements as mentioned earlier by Ashraf et al. (2008). The results supported many claims that it might take super long periods of time for health improvements to eventually benefit economy and/or its growth rate since the rate of adjustment was very slow as shown in the long-run relationship. Also, similar endogenous relationship of life expectancy and GDP was clearly shown in the long-term models. By proving that improvements in health could really benefit economic growth, it has become prominent for policymakers especially in developing countries to search for policies that continuously improve population's health status for potential benefits.

Murphy and Topel (2005) developed a framework to value improvements made in health by using individual's willingness to pay in *The Value of Health and Longevity*. Health improvements included increasing life expectancy and reducing mortality rates from cancer, cardiovascular, infectious diseases, etc. Results show that about $3.2 trillion per year would result to the 2000 population of USA given reductions in mortality rates over 30-year period from 1970-2000. By analyzing individual's willingness to pay, it could be seen that longer life span was valued because over a longer time horizon, utility of both goods and leisure accumulated. It then made sense to think about higher willingness to pay resulting from an increase in life expectancy since the value of remaining life increased over time. Nevertheless, the cost of improving health could be such a burden for responsible parties, i.e. government, and cost-benefit analysis should be comprehensively done. The net benefit of improving health, after accounting for the huge cost burden, was still positive in most of the cases. Policymakers still should consider various methods to improve health statuses in which the high implementation cost should be as worthwhile as possible. Different technologies to improve health facilities and/or health care schemes should be chosen carefully to match the characteristics of each nation or region.

What I haven't focused on is the public spending allocated to health sectors or public health expenditures. One reason I don't make use of data on public health expenditures is that I believe that public health expenditures are rather a figure of predetermined cost that might fail to correctly reflect the health outcomes or health status of population. Although public health expenditures can be 100% allocated to the right health sector to improve the well-being of people, it is still far from impossible to know exactly whether it does or it does not; in order to capture the outcomes, it is better to use health proxy that measures the outcome itself. There are interesting papers that relate health outcomes and health expenditures to which I found helpful, nevertheless.

One of them includes *The Effectiveness of Government Spending on Education and Health Care in Developing and Transition Economies* by Gupta, Verhoeven, and Tiongson (2002). The paper used cross-sectional data from 50 different countries to confirm the claim that an increased in public expenditures on both health and educational sector improved the accessibility to and achievements in schools as well as the reduction in children's mortality rates. The authors used an indicator to reflect quality of education or health status of a country instead of typical GDP as dependent variables. The education indicator was represented by the gross enrollment ratio in primary and secondary education, the persistence through Grade 4, and the primary school drop-out rates. Health indicator included infant mortality rates and child (under-5) mortality rates. In this paper, many variables such as percentage of population in the age group 0-14, per capita income, urbanization proportion, child nutrition were being controlled under education models; variables such as per capita income, adult illiteracy rates, access to sanitation and safe water, urbanization were being controlled under health models. Using OLS and 2SLS for both education and health, results show that a 5% increase in the share of primary and secondary education spending in total education public expenditures increased gross secondary enrollment rate by over 1%. A 1% increase of GDP in education expenditures raised gross secondary enrollment by more than 3%. Note that controlled variables were very significant in impacting the dependent variable. For health indicator, a 1% increase in health care expenditure decreased infant and child mortality rates by about 3 per 1000 live births. Looking at the results, the claim was verified to be correct that an increase in public expenditures on both health and educational sector improved the educational attainment and reduced mortality rates. Policymakers in developing and transition economies should consider these expenditures allocations to promote well-being across nations very vital, as well as keeping in mind the importance of controlling for certain variables.

The selected literatures that have been reviewed above are just part of many published literatures regarding the effects of health on economic growth to which I found relevant to my topic. I've done a very brief summary of all the literatures I've read in the Appendix. There are several more literatures that haven't been reviewed here due to the similar conclusion being reached and limited space. These literatures are very interesting and useful since many variables used in my models are extracted from these papers, depending on their availability and suitability. As you've read, almost every literature discussed above has reached similar conclusion that health impacts economic growth in one or another ways. The effects can be treated as direct in which health directly affects labor's productivity; healthier workers tend to work more productively with lower absenteeism, morbidity, and mortality rates (Knowles & Owen, 1997). Indirect effects through the accumulation of physical and human capital also take place. Though many literatures supported the claim that it does take so much time, even longer than a decade, for the improvements made in health to practically affect economic growth, the assertion on positively significant effects health might have on economic growth is still supported.

In this paper, I've tried to close the gaps in literature. Many literatures have still left rooms for further research, but due to unavailability of data and the inadequate knowledge to continue with the complications of these models, only some gaps can be continued with. For example, some researches haven't yet clearly explored the potential indirect effects health might have on output, instead of direct effects, due to limited data over time. Likewise, it is difficult to close this kind of gap. However, as I've been reading several papers, specific regions like health-economic growth relationship in ASEAN haven't been intensively analyzed and combination of health measures to estimate growths haven't been done. Also, past researches don't include UHC as one of the explanatory variables; this might be due to limited data across regions. By extracting relevant information from each paper—models, dependent variables, independent variables, and explanatory variables that seem to work within my framework are chosen accordingly and information regarding these data and methodology will be discussed in the next section.

III. Framework, Data, and Models

A. Theoretical Framework

This sub-section explains the theoretical framework I use to assess the relationship between health and economic growth. I extend Solow-Swan's growth model that takes Cobb –Douglas production function to include other independent variables which is 'education' and 'openness' which might explain the growth rate of GDP. More importantly, I include 'health' as explanatory variable. The model that will be used throughout this paper will look similar to $Y_{it} = A_{it}K_{it}^{\alpha}L_{it}^{\beta}E_{it}^{\delta}O_{it}^{\theta}H_{it}^{\gamma}$; where E, O, H represents education, openness, and health, respectively (variables like Y, A, K, L and subscript it have already been discussed above). However, it makes more sense to log-transform (logarithmic transformations) several variables, particularly, Y, K and L. I log-transform these variables to eliminate heteroskedasticity, a condition when the variable's variance and standard error are not constant over the entire range of the samples (DeLee, 2015), and to make the errors terms or residuals systematically distributed. Y, K, and L are generally measured by GDP, physical stock, and labor force; these variables have large variations among themselves since their data is large in value and each change (whether incrementing or decrementing) is very wide in absolute terms, so using logarithmic transformations is very necessary. Data on education, openness of the economy, as well as health, is, on the other hand, small in value, making each change in values very narrow; therefore no logarithmic transformations are needed.

B. Data

As theoretical framework being explained earlier, it is important to find valid measures of each variable to be put into the equation. This sub-section focuses on the explanation and relevance of each data, as well as its sources. Note that all panel data are for all ASEAN countries for the period 1990-2010, except Myanmar with data being unavailable; under second health proxy, accessibility to water source, data is available for only eight countries, excluding Brunei Darussalam with insufficient data.

Starting off with the only dependent variable Y or the output, literatures have used different measures to capture output which includes growth in output, GDP per worker, income per capita, real GDP growth rate per capita, total GDP, etc. Some microeconomic studies measure Y using hourly wage rates and annual hours worked. However, based on the availability of data on ASEAN countries, Y was tested against several measures including total real GDP, real GDP per capita, and also percentage change in GDP. After testing each measure to find the most suitable one, it seems that the logarithms of total real GDP yield the best results, consequently. The data on total real GDP are taken from Penn World Table (PWT) 7.1 (2012). However, data on GDP from Myanmar isn't available for the periods; the samples are then narrowed to only nine ASEAN countries. Though the newer version of PWT, PWT 8.0 (2013) is available, the real GDP data on the newer version is being classified according to the expenditures sides and output sides. To reduce complications in choosing between one of them, it is better to stick with the 7.1 version of data given that the variations between them aren't large. Specifically, in PWT 7.1, real GDP data is known as *tcgdp* or *Total PPP Converted GDP, G-K method, at current prices (in millions I$)*. The variable is therefore named as lGDP.

Independent variables of K and L, physical capital and labor force, are taken from PWT 8.0 and World Development Indicators (WDI). K or physical capital data is the capital stock each country has. It is measured at current purchasing power parity (PPPs) in millions of 2005 US$ (PWT 8.0). Labor force data, which is much more complicated, is computed by using data on labor force participation rate, total (% of total population ages 15+), from WDI multiplied by the data on populations (in millions) from PWT 8.0 to get the total number of people who are economically active or people who supply labor for the production of goods and services for each country during a specified period (WDI, 2014). They are named as $\mathrm{lCstock}$ and $\mathrm{lLforcePop}$, respectively.

Data on another two independent variables which are E and O, education and openness, are taken from Barro and Lee (2010) and PWT 7.1. Education is best gauged by average years of schooling, the average number of years of formal education received by people over age 15. Yet, since datasets came in 5-year intervals, repeating each entry over its 5-year period makes the data available throughout the 21-year period. Generally speaking, higher years of education show the higher education attainment of population in each country. Education should be added to the models because it raises human capital that increases GDP, simply, the more educated people are, the higher the productivity. Openness data, the ratio of total trade as a percentage of GDP computed by adding the total imports and exports together and dividing it by the GDP, is from PWT 7.1. In PWT 7.1, the data is known as *openc*, openness at current prices (%). I include openness as one of the independent variables because I believe that trade can increase GDP economically. The variables in the models are named as $\mathrm{Education}$ and $\mathrm{Openness}$.

What should be focused on in the models is the explanatory variable health, H. In this paper, health has six measures. Four of them measures health outcomes, and two of them measures health inputs. Health outcome, actually, should be viewed as a more reliable source of data since they do capture the final outcomes rather than being the predetermined indicator predicting outcomes that are not yet happening.

The discussion of the four measures of health outcomes will be done first, followed by the two health inputs. The first health proxy is most widely used, life expectancy at birth. Life expectancy at birth specifies the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life (WDI, 2014); this implies that the higher the number, the longer the life span and/or the healthier the people. People with higher life expectancy tend to be healthier and can work more during the specified time period. Developed country like Singapore has average life expectancy across 1990-2010 of about 78.34 years; whereas, developing country like Cambodia has the figure stood at 62.37 years. In the regression results which will be shown on the next section, life expectancy is named as $\mathrm{Hproxy1LE}$ which stands for health proxy 1: life expectancy.

The second one is mortality rates of children under-5 (per 1,000 live births), $\mathrm{Hproxy3MU5}$. According to definition by WDI, under-5 mortality rate is the probability per 1,000 that a newborn baby will die before reaching age 5, if subject to age-specific mortality rates of the specified year (estimations provided by the UN Inter-agency Group for Child Mortality Estimation). Literally, the lower the rates, the more number of babies being alive, signaling the better health status of the population. This data is also taken from the WDI. Mortality rates imply the quality of health facilities in each country that is being reflected through health status of the population. Therefore, mortality rates are predicted to be negatively correlated with GDP, ceteris paribus.

The third proxy is mortality rates of infants (per 1,000 live births), $\mathrm{Hproxy4MI}$, the number of infants dying before reaching the age of one (WDI, 2014). Again, data is taken from WDI, with estimations given by the UN Inter-agency Group for Child Mortality Estimation. Using the same concept with under-5 mortality and combining the rates together, the lower the number as more infants and children being alive reflects good health status of the population. Moreover, it is also expected that mortality rates of infants will negatively affect GDP and/or its growth rate.

The fourth measure of health output indicates the average ASR, $\mathrm{Hproxy6ASRA}$. ASR is the probability of a 15-year-old living to the age of 60, if subject to current age-specific mortality rates between those ages (WDI, 2014). ASR data, however, can't be found directly. The only available data on WDI is the adult mortality rates (AMR), the probability of a 15-year-old dying before reaching age of 60. Directly using AMR data would create huge confusion, so transforming the data into ASR by using the equation $ASR = 1 - AMR$ is easier. Also, WDI offers the data on AMR separately for females and males. To reduce complications and cumbersome processes, I use the average of both datasets since the variations between them aren't large. ASR, in contrast to mortality rates, is expected to positively affect GDP since higher probability of surviving directly constitutes to more output being produced.

Under health inputs, only two proxies are being used. The first one is the accessibility to water sources in rural areas, $\mathrm{Hproxy2H2OR}$, with data taken from WDI. WDI defines this variable as the percentage of population using an improved drinking water source which includes piped water on premises (piped household water connection located inside the user's dwelling, plot or yard), and other improved drinking water sources (public taps or standpipes, tube walls or boreholes, protected dug wells, protected springs, and rainwater collection). People are at least ensured to have access to safe water, which implies that their basic needs for good health are guaranteed. However, as explained earlier, access to safe water in rural area is only a predetermined indicator that only measures the inputs, more access typically indicates hygienic environment–that's all. Having access to safe water guarantees that basic needs are met but it doesn't directly signify health status of population, which makes more sense to be measured using other health outcomes proxy. I include this variable to make the relationship between different health proxies and GDP easier to be analyzed given as many proxies as possible (though each of the proxy reflects different things). Under this proxy, however, the samples are reduced to 8 countries, given that the data for Brunei Darussalam isn't available. Also, little modifications have been made to Singapore's data, since Singapore is geographically very small, the data on improved water access in urban area is typically the same as in rural areas (data for rural areas isn't available in Singapore). Similarly, data is taken from WDI.

The most important health measures I want to focus on is the UHC, $\mathrm{Hproxy6UHC}$. In this paper, UHC is the only variable represented using dummy, in which 1 means that the country provides UHC in that specified period of time and 0 means the absence of UHC. The data for UHC are taken from many sources, mostly qualitative articles that provide information on the extent of UHC implementation in each ASEAN country. Searching for data on UHC is the most time-consuming task in this paper due to the fact of mismatched information provided by each source of information, especially on the obscure distinction of UHC. UHC, as explained briefly above, should be providing (almost) 100% of the citizens with basic health needs through an affordable and accessible system. UHC should act as a health solution for every citizen who can or cannot, by himself/herself, pays for his/her health needs. Given this condition, I consider a country to have UHC if and only if its (almost) entire citizens are ensured with basic health care services.

One of the countries with UHC is Singapore. Singapore's Ministry of Health (MOHS) explained its UHC as a system of the combination of individual responsibility and public provision. Singapore uses market mechanisms, supply and demand, to encourage competition in order to provide the best health care services for its citizens. Market mechanisms also help in improving health care services and facilities throughout the time. There are four tiers of protection in Singapore. The first tier is the subsidies provided by the Government. The second tier of protection is a so-called *Medisave*, a medical savings accounts mandatory for all Singaporeans to be able to pay for their health expenditures, which is most needed at the retirement age. The third tier is *MediShield*, a basic medical insurance scheme which help patients for expenses paid on major illnesses or serious treatment. MediShield accompanies Medisave in case there is a serious prolonged treatment that used up the savings pool (MOHS, 2015). The last tier of protection is *Medifund*, a Government-set-up endowment fund use for Singaporeans who are truly needy given that all other sources of funds are depleted (MOHS, 2015). Medisave, MediShield, and Medifund was introduced and implemented in the year 1984, 1990, and 1993, respectively (MOHS, 2015). This obviously shows that Singapore has its UHC in practice for few decades.

Another ASEAN country with UHC implementation is Malaysia (Minh et al., 2014). Malaysia has achieved UHC since 1980s (ASEAN Plus Three UHC Network, 2014). Like Singapore, Malaysia has a mixed financial system for health care, both private and public. Typical private health insurance is available for citizens who want to pursue additional insurances. Public sectors also provide basic medical insurance for employees. Taxation is the main source of the public health sector's funds. Similar to Singapore's Medisave, Employee Provident Fund (EPF) is also a compulsory savings scheme for citizens to ensure their security after retirement and health-related expenses. There is also a Social Security Organization (SOCSO) scheme for formal workers who earn lesser than RM3000. In Malaysia, government is still major funds provider for those in need and voluntarily leaves private health services to affordable citizens (Chua & Cheah, 2012).

Thailand, however, has achieved its UHC implementation in the year 2002. The implementation followed the Universal Coverage Scheme (UCS) or the "30-Baht Scheme". Funds for financing this scheme were achieved through reallocation of budgets and increase in taxes on products such as luxury goods, alcohol, and tobacco. The benefits citizen receive have been evolving until they reach the poorest households for them not to suffer any financial hardships. Along with the UCS scheme, the two other health insurance schemes which makes the implementation of UHC possible include the Civil Servant Medical Benefit Scheme (CSMBS) and the compulsory Social Security Scheme (SSS). The implementation of UHC has made it possible for Thai citizens to meet their basic health demands as well as reducing expenditures on severe, prolonged treatment (Tessier, 2014). The health care packages offer so many benefits ranging from basic health prevention and care to an access to Antiretroviral therapy (ART), a treatment for Human Immunodeficiency Virus (HIV) (Chowdhury & Phaholyothin, 2012).

Brunei Darussalam has had its UHC implemented since 1958. Its UHC, being easily affordable and accessible, is provided by the government for all Bruneians and residents. Voluntary old age pension benefits can be claimed for people age over 55 and contributions are made from salaries. Disability benefits are widely provided for disabled people under some requirements. Employers are responsible for covering the medical costs that incurred as a result of certain works or tasks. Moreover, there are also unemployment benefits for people who are unemployed and also survivor benefits for descendants of a deceased person (Ministry of Health Brunei, 2015).

Out of nine ASEAN countries in the samples, only four that are explained earlier are considered having UHC. The rest which includes Cambodia, Indonesia, Laos, Philippines, and Vietnam haven't yet reached the extent where the entire population is covered by UHC. Minh et al. (2014) said Cambodia is still now struggling to achieve UHC since providing sufficient health funding for both formal and informal sectors is very difficult. Cambodia's government health expenditures are relatively low making the funding from public sectors even more arduous. In addition, health insurance scheme is found unfamiliar in most of the areas making the concept of UHC far from possible in the meantime.

Indonesia, however, has already started the implementation of UHC in 2014. Though it is not yet fully done, Indonesia plans to achieve UHC in 2019 (Sutiwisesak, 2013). Due to limited infrastructure which includes inadequate health workforces, health facilities, etc., the progress of implementing UHC in Indonesia is really slow. Furthermore, given the fact that Indonesia is a relatively large country (ranks 6^{th} in Asia or 1^{st} in ASEAN), making health care equally accessible throughout the areas is very challenging. A development to UHC using Health Information System (HIS) is, nevertheless, on progress right now. This might be the efficient tools for Indonesia to eventually achieve UHC in 2019 as planned (Minh et al., 2014).

Laos, with 0 as dummy variable under UHC, is also experiencing similar scenarios. Out-of-pocket health expenditures are still very high in Laos as the level of public spending on health is too low. Poverty that leads to poor quality of health care has long been a problem in the country, together with the problem on geographical dispersion of population makes UHC a far-reaching goal. Since UHC can be viewed as an important mechanism to ensure citizens with basic health care, Laos does plan to achieve it in 2020, accordingly (Minh et al., 2014).

Philippines has also planned to achieve UHC by 2016 (ASEAN Plus Three UHC Network, 2014). An increase in insurance coverage without a corresponding increase in the funding impedes the achievement of UHC. The problems of health inequities between regions are also being addressed in order to stick with the 2016 implementation plan (Minh et al., 2014).

The last country to be discussed is Vietnam, also has UHC's representation as 0. According to Minh et al. (2014), Vietnam is a bit different from its non-coverage peers since almost two-thirds of the population has basic health insurance. The coverage tends to cover only formal sector workers, leaving the informal sector workers uninsured. The difficulty also arises as a result of the noticeable inequalities between the rich and the poor especially in terms of health facilities that seem to accommodate only the rich. People in rural areas also face the troubles of not having enough health infrastructures due to limited budget. Vietnam's plan is to cover 80% of population by 2020 (ASEAN Plus Three UHC Network, 2014).

To sum up the foregoing explanations of each country's UHC, I use 1 as a dummy variable to indicate the successful implementation of UHC within the specified time period, and 0, otherwise. Brunei Darussalam, Malaysia, Singapore, and Thailand's dummy variables are all 1 (with Thailand 0 over the 1990-2001 range and 1 from 2002-2010). Dummy variables for Cambodia, Indonesia, Laos, Philippines, and Vietnam are consequently labeled 0. Summary statistics of each variable which includes (1) number of observations (2) standard deviation (3) arithmetic mean (4) minimum value (5) maximum value are reported in the Appendix.

C. Models

Under this sub-section, several regression methods, as well as model specifications, will be discussed and finally selected. Eventually, one of them will be preferred over the others with clear explanation to support its use. Given several independent variables, I decided to start my first specification by just simply running $\mathrm{lCstock}$ and $\mathrm{lLforcePop}$ (K and L) on lGDP. I keep on adding other independent variables (i.e. $\mathrm{Education}$ and $\mathrm{Openness}$) as more specifications are included. Under specifications that include health variables, one of the four health outcomes measures (i.e. $\mathrm{Hproxy1LE}$, $\mathrm{Hproxy3MU5}$, $\mathrm{Hproxy4MI}$, $\mathrm{Hproxy6ASRA}$) is being tested one at a time. $\mathrm{Hproxy5UHC}$ itself is also being tested with other independent variables. As more specifications on health are added, I keep on combining each proxy of health outcomes with each of the two health inputs proxies (i.e. $\mathrm{Hproxy2H2OR}$, $\mathrm{Hproxy5UHC}$) and eventually combining each proxy of health outcomes with both proxies of health input together at one time, yielding 20 specifications all together. The regression results will be shown on the next section.

In deciding which regression methods should be used, brief explanation and validity of each method must first be thoroughly explained. The first regression method people think of when running independent variable(s) on dependent variable to find its magnitude of effect is the Ordinary Least Squares (OLS), a generalized linear modeling (Hutcheson, 2011). This paper focuses on the analysis of panel data, a multi-dimensional data involving measurements over time; typical panel data exhibits panel data effects in which it is often not suitable to use OLS. Two appropriate models to be used with panel data are (1) Random Effects Model and (2) Fixed Effects Model. The definition of fixed effects model will be provided later.

Starting with random effects model, Torres-Reyna (2007) explained random effects model as "a model where the variation across entities is random, as its name suggests, implying that the variation is uncorrelated with the independent variables included." Random effects model can be illustrated using the equation $Y_{it} = \alpha + \beta X_{it} + u_{it} + \varepsilon_{it}$; where u_{it} represents between-entity error and ε_{it} represents within-entity error. The significant part of random effects model is based on the assumptions that variations across entities (i.e. differences between countries) partially or fully affect the dependent variable, in this case lGDP. In other words, random effects model works only under the assumption that each entity's error term has no correlation with other independent variable (i.e. each county's specific characteristics is not correlated with any other independent variables).

Theoretically, it would be least preferred to run panel data using a simple OLS. I've tried to verify this assertion using a test in Stata called Breusch-Pagan Lagrangian Multiplier (LM) test, under the command `xttest0`, to test if there exists any panel effect across entities or not. The test helps in deciding which models between a simple OLS and random effects model is preferred. LM's test null hypothesis assumes that the variance across entities is zero, indicating an absence of panel effects. I've attempted to perform the LM test on several combinations of independent variables; results show that the null hypothesis on zero variance is completely rejected. However, illustrating all of the test results on different models would be cumbersome and irrelevant. Note that results show that switching from one health proxy to another doesn't influence the test statistics. Hence, I decided to show the test results on only two models. The first model includes lCstock, lLforcePop, Education, Openness, Hproxy1LE, Year.

Test Results 1. Breusch-Pagan Lagrangian Multiplier (LM) test

Dependent variable: lGDP

Independent variables: lCstock, lLforcePop, Education, Openness, (Year)

Explanatory variables: Hproxy1LE

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        lGDP[Country,t] = Xb + u[Country] + e[Country,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                    lGDP |   2.56942       1.602941
                       e |  .0107769       .1038119
                       u |  .0663877       .2576582

        Test:   Var(u) = 0
                             chibar2(01) =   409.07
                          Prob > chibar2 =   0.0000
```

By looking at the test statistics at the last line, 0.0000 indicates that the null hypothesis should be rejected implying the presence of panel effects. In simpler words, random effects model with variations across entities is preferred to OLS. Using OLS might cause the results to be biased in which OLS signals the zero variance across entities. The test was performed repeatedly with a slight change in the model: an addition of the variable of interest UHC or Hproxy5UHC.

Test Results 2. Breusch-Pagan Lagrangian Multiplier (LM) test

Dependent variable: lGDP

Independent variables: lCstock, lLforcePop, Education, Openness, (Year)

Explanatory variables: Hproxy1LE, Hproxy5UHC

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        lGDP[Country,t] = Xb + u[Country] + e[Country,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                    lGDP |    2.56942       1.602941
                       e |     .01074       .1036338
                       u |   .0872461       .2953744

        Test:   Var(u) = 0
                             chibar2(01) =   437.07
                          Prob > chibar2 =   0.0000
```

As shown, there is no change in the test results even though another variable is added. This indicates a strong preference toward the random effects model.

What is more important than determining between OLS and random effects model is to determine between random effects model and fixed effects model. Torres-Reyna (2007) explained fixed effects model as "a model that helps in analyzing only the impact of variables that vary over time (time-variant variables)". Fixed effects models work under the assumptions that specific characteristics within an entity might bias the coefficients' results (i.e. each country is assumed to have specific-country characteristics that might bias lGDP). This also implies that correlation exists between each entity's error term and independent variables. Fixed effects model generally assumes that each country is different (maybe because of political or sociological factors) and those differences shouldn't be correlated with one another; as a result, those differences should be controlled in fixed effects model. Fixed effects model can be represented using $Y_{it} = \alpha_i + \beta_1 X_{it} + u_{it}$; where u_{it} represents error term.

Given these explanations, the distinct differences between random effects model and fixed effects model is the assumptions of correlation between entity's error term and independent variables. Random effects model assumes no correlation while fixed effects model controls for the presence of correlation. Another test is performed to decide between fixed effects model and random effects model called Hausman test, under the Stata's command `hausman fixed random`. The null hypothesis indicates that random effects model is preferred or that the entity's error term is uncorrelated with the independent variables; alternative hypothesis suggests that fixed effects model should be used.

Similar attempts to the LM test have been made. Combining several independent variables yield the same test statistics. Again, demonstrating every model would be burdensome; thus, two models will be used to show the test statistics. Note also that changing the combination of the variables and switching between health proxies result in no change to the test statistics. The first model includes lCstock, lLforcePop, Education, Openness, Hproxy6ASRA, Year.

Test Results 3. Hausman test

Dependent variable: lGDP

Independent variables: lCstock, lLforcePop, Education, Openness, (Year)

Explanatory variables: Hproxy6ASRA

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
     lCstock |    .305853     .3956643       -.0898114        .0113456
  lLforcePop |    .545182     .4106668        .1345152        .2015711
   Education |    -.04037    -.0113617       -.0290083               .
    Openness |  -.0002841    -.0003009        .0000168               .
 Hproxy6ASRA |   .0031776     .0045331       -.0013554        .0000716
        Year |   .0376552     .0250207        .0126345        .0043881
------------------------------------------------------------------------------
                 b = consistent under Ho and Ha; obtained from xtreg
      B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                 chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                         =       71.56
               Prob>chi2 =      0.0000
               (V_b-V_B is not positive definite)
```

The test statistics 0.0000 shows that the null hypothesis on no correlation between entity's error term and independent variables or the preference toward random effects model is again completely rejected favoring fixed effects model. The panel data across countries in this case can be said to have country-specific characteristics which should be correctly controlled under the use of fixed effects model. The second model simply adds the variable of interest Hproxy5UHC.

Test Results 4. Hausman test

Dependent variable: lGDP

Independent variables: lCstock, lLforcePop, Education, Openness, (Year)

Explanatory variables: Hproxy6ASRA, Hproxy5UHC

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
     lCstock |    .2732156     .3965473       -.1233316         .029802
  lLforcePop |    .3749672     .4177337       -.0427664        .2544803
   Education |   -.0356334     -.017696       -.0179374               .
    Openness |   -.0000962    -.0003766        .0002804        .0001016
 Hproxy6ASRA |    .0030622     .0044883       -.0014261        .0001008
  Hproxy5UHC |    -.075793     .0470094       -.1228024        .0390355
        Year |    .0430073     .0256214        .0173859        .0065085
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from xtreg
           B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       58.34
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

Again, adding Hproxy5UHC doesn't change the test statistics. The significant test statistics favors the use of fixed effects model in running this set of data. Now, after performing few tests to determine the most suitable regression methods given this dataset, it can be seen that fixed effects model is the most appropriate and preferable. As all of the models specifications are being explained earlier, the next section will show the results of the regressions in which they might or might not support the assertion made earlier along with the conclusions from the previous literatures reviews.

IV. Empirical Results and Interpretation

A. Empirical Results

In this sub-section, the regression results under fixed effects model will be shown. The regression results under OLS, with obvious differences in the coefficients and significance level will be shown on the Appendix. As explained earlier on the specifications of the model, the first three specifications only include independent variables, yet, no explanatory variables on health is included. Note that this sub-section only discusses the interpretation of results in brief. The full interpretation will be found in the next sub-section. Also, note that the term 'regressors' and' independent variables' will be used interchangeably.

Table 1. Regression results–independent variables only
Dependent variable: lGDP

VARIABLES	(1) FE Model 1	(2) FE Model 2	(3) FE Model 3
lCstock	0.253***	0.291***	0.284***
	(0.0615)	(0.0482)	(0.0581)
lLforcePop	0.817	0.735	0.720
	(0.609)	(0.518)	(0.533)
Education		-0.0724	-0.0731
		(0.0413)	(0.0425)
Openness			0.000218
			(0.000944)
Year	0.0412**	0.0487***	0.0490***
	(0.0154)	(0.0128)	(0.0136)
Constant	4.634	5.323	5.731
	(10.97)	(8.735)	(9.191)
Observations	189	189	189
R-squared	0.942	0.946	0.947
Number of Country	9	9	9
Country FE	YES	YES	YES

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The results show that both lCstock and lLforcePop are positively correlated with lGDP in every model, validating the theory that both physical capital and labor force increase output (though the latter shows no sign of significance). Significance is shown through the presence of asterisks appearing after the coefficients, with standard errors of each variable shown in the following parentheses. The number of asterisks signifies the significance level. Education, which also shows no sign of significance, exhibits a negatively correlation with lGDP. This contradicts the theories verified in many literatures that education constitutes to labor's productivity through knowledge accumulation. However, as mentioned earlier in Section III, data on education as measured by average years of schooling signals huge data clustering problem due to repeated entries in each 5-year intervals, implying little variations throughout the range. Since the results show no significance level on education, negative sign is not being concerned. Openness's coefficient is also positively small, with no significance level. The next regression results will include the specifications with explanatory variable included.

Table 2. Regression results—one health variable at a time (excluding Hproxy2H2OR) Dependent variable: lGDP

	(4)	(5)	(6)	(7)	(8)
VARIABLES	FE Model 4	FE Model 5	FE Model 6	FE Model 7	FE Model 8
lCstock	0.268***	0.264***	0.268***	0.306***	0.223**
	(0.0527)	(0.0533)	(0.0546)	(0.0560)	(0.0829)
lLforcePop	0.608	0.890*	0.913*	0.545	0.382
	(0.383)	(0.460)	(0.476)	(0.368)	(0.674)
Education	-0.0257	-0.0408	-0.0440	-0.0404	-0.0618
	(0.0313)	(0.0374)	(0.0374)	(0.0335)	(0.0416)
Openness	-0.000560	5.81e-06	1.38e-05	-0.000284	0.000544
	(0.000780)	(0.000835)	(0.000853)	(0.000801)	(0.00092)
Hproxy1LE	0.0373***				
	(0.0108)				
Hproxy3MU5		-0.00347			
		(0.00192)			
Hproxy4MI			-0.00538		
			(0.00318)		
Hproxy6ASRA				0.00318**	
				(0.00119)	
Hproxy5UHC					-0.145
					(0.123)
Year	0.0359**	0.0382**	0.0377**	0.0377***	0.0584**
	(0.0119)	(0.0138)	(0.0143)	(0.0112)	(0.0183)
Constant	5.338	3.585	3.160	5.385	12.70
	(6.720)	(7.706)	(7.986)	(6.339)	(12.26)
Observations	189	189	189	189	189
R-squared	0.956	0.951	0.951	0.955	0.948
Number of Country	9	9	9	9	9
Country FE	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

According to the regression results in `Table 2`, only life expectancy and ASRA (average of adult survival rates) are statistically significant among the 5 measures (the former is at 1% and the latter is at 5% significance level). They also have positive sign in front, which indicates a 1-year increase in life expectancy increase GDP by $e^{0.0373} = 1.038$ or approximately 3.8%; a 1-unit increase in ASRA corresponds to $e^{0.00318} = 1.0032$ or 0.32% increase in GDP. Benoit (2011) explained the interpretation of log-linear model by saying that a one unit increase in (non log-transformed) independent variables multiplies the expected value of log-transformed dependent variable by e^{β}.

In this case, mortality rates of both under-5 children and infants seem to not statistically affect GDP, even though their corresponding sign makes sense (negative sign in front of both variables indicates a reverse correlation in which 1-unit increase in mortality rates decrease GDP instead of increasing it). As aforementioned, mortality rates are assumed to negatively impact output as an increase in mortality rates decreases human capital which leads to a decline in productivity. Though mortality rates' coefficients show no sign of significance, the logical reason of having negative sign is still supported. By looking at the variable of interest $\mathrm{Hproxy5UHC}$, the presence of negative sign of the parameter estimates implies that the absence of UHC is preferable. However, the fixed effects model 5 should be ignored since no sign of significance is shown with the explanatory variable.

The next sets of specifications combine the variable of interest UHC together with health proxy. From fixed effects model 8, UHC doesn't play any role in explaining GDP growth. Combing them with health measures might then yield more statistically significant results. `Table 3`, on the next page, show the regression results.

Table 3. Regression results–combining each proxy of health outcomes with Hproxy5UHC Dependent variable: lGDP

VARIABLES	(9) FE Model 9	(10) FE Model 10	(11) FE Model 11	(12) FE Model 12
lCstock	0.232**	0.223**	0.224**	0.273**
	(0.0814)	(0.0814)	(0.0820)	(0.0869)
lLforcePop	0.411	0.644	0.654	0.375
	(0.566)	(0.654)	(0.663)	(0.558)
Education	-0.0205	-0.0347	-0.0373	-0.0356
	(0.0346)	(0.0391)	(0.0393)	(0.0368)
Openness	-0.000343	0.000245	0.000264	-9.62e-05
	(0.000762)	(0.000794)	(0.000807)	(0.000763)
Hproxy1LE	0.0361**			
	(0.0113)			
Hproxy3MU5		-0.00327		
		(0.00199)		
Hproxy4MI			-0.00508	
			(0.00329)	
Hproxy6ASRA				0.00306**
				(0.00123)
Hproxy5UHC	-0.0861	-0.101	-0.107	-0.0758
	(0.126)	(0.127)	(0.127)	(0.125)
Year	0.0419*	0.0454*	0.0453*	0.0430**
	(0.0183)	(0.0201)	(0.0203)	(0.0178)
Constant	9.479	8.571	8.420	9.032
	(10.82)	(11.87)	(12.02)	(10.70)
Observations	189	189	189	189
R-squared	0.956	0.952	0.952	0.955
Number of Country	9	9	9	9
Country FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 shows the results which is very similar to that of Table 2. Life expectancy and ASRA are the only two proxies that display significance level at 5%. Combining them with UHC changes the parameter estimates by a tiny bit $e^{0.0361} = 1.037$ or 3.7% increase in GDP corresponding to a 1-year increase in life expectancy and $e^{0.00306} = 1.0031$ or 0.31% corresponds to a 1-unit increase in ASRA. Both mortality rates still show no sign of significance, along with the dummy variables UHC. Table 4 shows the specifications in combing health outcomes with the variable water access health input. The results are shown on the next page.

Table 4. Regression results—combining each proxy of health outcomes with Hproxy2H2OR
Dependent variable: lGDP

VARIABLES	(13) FE Model 13	(14) FE Model 14	(15) FE Model 15	(16) FE Model 16
lCstock	0.230***	0.222***	0.222***	0.236***
	(0.0435)	(0.0478)	(0.0484)	(0.0613)
lLforcePop	1.410***	1.531***	1.529***	1.431***
	(0.327)	(0.218)	(0.218)	(0.390)
Education	0.0287	0.0267	0.0270	0.0259
	(0.0177)	(0.0179)	(0.0179)	(0.0168)
Openness	-0.000820	-0.000768	-0.000761	-0.000756
	(0.000766)	(0.000693)	(0.000694)	(0.000728)
Hproxy1LE	0.0109			
	(0.0146)			
Hproxy3MU5		0.000193		
		(0.00248)		
Hproxy4MI			0.000120	
			(0.00403)	
Hproxy6ASRA				0.000709
				(0.00166)
Hproxy2H2OR	0.0168**	0.0197***	0.0195***	0.0176**
	(0.00494)	(0.00533)	(0.00534)	(0.00598)
Year	0.00994*	0.00971	0.00964	0.00995
	(0.00521)	(0.00516)	(0.00532)	(0.00588)
Constant	-6.672	-7.949*	-7.910*	-7.056
	(4.470)	(3.767)	(3.786)	(4.881)
Observations	164	164	164	164
R-squared	0.973	0.973	0.973	0.973
Number of Country	8	8	8	8
Country FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note that in this set of specifications, the variable lLforcePop is now statistically significant in every model. Combining each proxy of health outcomes with the health input Hproxy2H2OR eliminates significance in every other health proxy. This implies that according to these models, health outcomes proxy doesn't affect GDP, only health input measures does. A 1-unit increase in the percentage of improved water access in rural areas raises GDP by approximately $e^{0.0168}, e^{0.0197}, e^{0.0195}, e^{0.0176} = 1.017, 1.0199, 1.0197, 1.0178$ or 1.7%, 1.99%, 1.97%, and 1.78% when combining with life expectancy, under-5 mortality rates, infant mortality rates, and ASRA, respectively.

Table 5. Regression results—combining each proxy of health outcomes with both Hproxy2H2OR and Hproxy5UHC
Dependent variable: lGDP

VARIABLES	(17) FE Model 17	(18) FE Model 18	(19) FE Model 19	(20) FE Model 20
lCstock	0.258***	0.251***	0.251***	0.266***
	(0.0517)	(0.0563)	(0.0562)	(0.0628)
lLforcePop	1.611***	1.736***	1.735***	1.639**
	(0.433)	(0.306)	(0.307)	(0.486)
Education	0.0261	0.0241	0.0243	0.0231
	(0.0180)	(0.0171)	(0.0172)	(0.0171)
Openness	-0.00102	-0.000978	-0.000972	-0.000973
	(0.000683)	(0.000681)	(0.000680)	(0.000664)
Hproxy1LE	0.0106			
	(0.0142)			
Hproxy3MU5		0.000171		
		(0.00241)		
Hproxy4MI			0.000124	
			(0.00391)	
Hproxy6ASRA				0.000738
				(0.00158)
Hproxy2H2OR	0.0175**	0.0203***	0.0202***	0.0183**
	(0.00520)	(0.00540)	(0.00543)	(0.00612)
Hproxy5UHC	0.0718	0.0746	0.0748	0.0770
	(0.0766)	(0.0687)	(0.0693)	(0.0734)
Year	0.00398	0.00351	0.00344	0.00359
	(0.0111)	(0.0102)	(0.0103)	(0.0113)
Constant	-10.75	-12.14*	-12.12*	-11.35
	(6.977)	(5.811)	(5.823)	(7.170)
Observations	164	164	164	164
R-squared	0.974	0.973	0.973	0.973
Number of Country	8	8	8	8
Country FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The last sets of specifications include adding both UHC and water access together and combining both of them with each of the health outcome proxy. Similar to Table 4, the results show that improved water access is the only prominent regressor among all health regressors. An increase in 1-unit Hproxy2H2OR shows $e^{0.0175}, e^{0.0203}, e^{0.0202}, e^{0.0183} = 1.0177, 1.021, 1.02, 1.018$ or 1.77%, 2.1%, 2.0%, and 1.8% increase in GDP, respectively. More importantly, UHC remains insignificant throughout the models. Other health outcomes are now insignificant in these specifications. The next sub-section provides clear interpretation of these results. Note that using fixed effects model yield the same result with using another regression method called Least Squares Dummy Variables (LSDV), in which its results are available upon request.

Having very clear picture of the effects of each health proxy now, it is easier to only focus on the model that works. Since specifications from `Table 4` and `Table 5` combine health proxies together, in which the problem of multicollinearity, the correlation between two or more independent variables, (will be fully discussed in Section 5) arises, dropping sign of significance and creating misleading results, it is now important to focus only on `Table 2` and `Table 3` with main concentration on the meaning of each regression's result.

B. Interpretation

As shown in the results above, it can be seen that, without adding the $\mathrm{Hproxy2H2OR}$ variable, only life expectancy and ASRS are statistically significant in `Table 2`. The effects of both seem logical– 3.8% and 0.32% increase in GDP corresponding to a 1-unit increase of life expectancy and ASRA. Mortality rates of both under-5 and infants, though having logically negative effects, show no sign of significance. The decrease in mortality rates implies the increase in survival rates which in turns lead to higher productivity, ceteris paribus. What is notable are the specifications in `Table 4`, where $\mathrm{Hproxy2H2OR}$ is included. The results show that in specifications 13 to 16, the addition of $\mathrm{Hproxy2H2OR}$ variable eliminates the significance of all the other health variables, including life expectancy and ASRA that were statistically significant in the previous specifications. Not only that significance was eliminated, the coefficients for both mortality rates under-5 and infants exhibit reverse correlation. Mortality rates now show positive relationship with total GDP, which seems a bit illogical. Since the analysis takes GDP as dependent variable instead of GDP per capita, increase in mortality rates should negatively impact GDP; increasing mortality rates indicates smaller labor force causing a decline in total productivity. The reason to support the poorly determined coefficients or parameter estimates, including the reverse sign in front of mortality rates variables, seems to be the presence of multicollinearity.

Multicollinearity is the phenomenon when two or more independent variables in the specifications are correlated (Wikipedia, 2015). The problem causes misleading coefficients and results since the effects can be explained through one independent variable, having the unnecessary variable leads to confusing results. Multicollinearity frequently happens when two regressors explain or represent similar features or characteristics. Apparently, $\mathrm{Hproxy2H2OR}$, which measures the percentage of accessible improved water source, shows the extent in which population are at least provided with basic health care (i.e. clean and safe water) are expected to be highly correlated with other health outcome proxies that measure similar features i.e. to what extent the population are "healthy". Nevertheless, the claim on having multicollinearity as a problem can be tested using `corr` command in Stata. The results will be shown on the next section that explains the limitations of these models.

Setting aside $\mathrm{Hproxy2H2OR}$, the intuition behind having only two of the four health outcome proxies significant is the outcome each proxy captures. Life expectancy measures the average years people are expected to live in each country given specified time period. In wealthy countries where malnutrition and diseases prevalence are not a problem, people are expected to have longer life span thus their life expectancies are generally high; the opposite goes to developing countries. ASRA, similar to life expectancy, measures the probability that a 15 year-old can live to the age of 60. ASRA is expected to be high for affluent countries where causes of mortality are reduced due to sufficient and quality health infrastructures and facilities. These two measures can be regarded as a reliable and viable measure of estimating health statuses of population.

On the contrary, mortality rates of both under-5 and infants measure only probability of surviving beyond a specified age ranges. After that specified age ranges, general living condition in a country might be improved and overall health statuses might be unaffected by those mortality rates. Reidpath and Allotey (2003) pointed out that infant mortality rates have been regarded as a highly sensitive measure of health statuses. The association between the causes of these mortalities and other factors including economic development, living conditions, environment quality are obvious. Infant mortality rates might decrease but health statuses in general might remain stagnant, not improving at all. To say that under-5 and infant mortality rates are not a good measure of health is not in a way correct, nevertheless. Reidpath and Allotey (2003) also suggested that using infant mortality rates as health measures can be reliable if resources to other measures are unavailable and if sampling countries have infant mortality rates greater than 10, corresponding to the results in their paper. However, in our samples, Brunei Darussalam's, Malaysia's, and Singapore's infant mortality rates are lower than 10–this fact might fail to make mortality rates a good measure of health statuses. The pitfall of certain data, therefore, can make the variables insignificant.

Looking at the variable of interest $\mathrm{Hproxy5UHC}$ which doesn't show sign of significance in any of the specifications, it might be clear that UHC, by itself, doesn't contribute to GDP. Recall that UHC is represented quantitatively by dummy variables 1 and 0 where 1 represents the presence of UHC or 0 otherwise. Dummy variables of UHC, however, don't reflect the efficiency of UHC. UHC might be presented in a country but it might not statistically improve health statuses of the population given that the average health statuses are already good. Furthermore, UHC ensures that basic health demand is met but it doesn't necessarily imply longer life span or the better health statuses throughout the range. Since UHC is more like a predetermined indicator of health statuses rather than the final outcomes, having the variables insignificant, in a way, makes sense.

Therefore, life expectancy and ASRA seem to be the most reasonable and reliable health proxies in which they directly reflect the general health status of population. However, these models are far from perfect–there might be many more variables that should be incorporated into the models that might or might not impact the parameter estimates, changing the overall results. Correspondingly, given this amount of available information, the models above have been used at their maximum capacity to explain the relationship between variables.

V. Limitations

There are still many limitations to this paper, since econometrics model is one of the hardest to be working with. I classify this section into three sub-sections to carefully explain each limitation or problems, some of them can be addressed and some cannot.

A. Heteroskedasticity and Autocorrelation

Writing a quantitative research paper, especially those that deal with econometrics model, must be done with caution. Seemingly easy, interpreting the regression results are actually done under prudence. The reason is that there are many problems to the regression itself, might be due to the model misspecifications, data biases, etc. Overlooking these problems might cause the regression results to be biased and misleading. One of the main problems with econometrics model is heteroskedasticity, as aforementioned. Heteroskedasticity is the condition when the variable's variance and standard error are not constant over the entire range of samples (DeLee, 2015) causing biases in the regression results and misleading statistical inferences. However, correcting for the problem of heteroskedasticity, through the assumption of its presence, is already done by rectifying standard errors. Even though the presence of heteroskedasticity is unknown, using robust standard errors while performing the regression analysis by adding `robust` to Stata `xtreg` command eliminates the problem leading to reliable results.

Not only does the command `robust` correct for the problem of heteroskedasticity, but also the problem of autocorrelation. Autocorrelation is the condition where entity's error terms are correlated with one another over time. Autocorrelation violates the standard classical econometric model as it will bias the regression results and standard errors, correspondingly. Using robust standard errors, however, controls for both heteroskedasticity and autocorrelation.

B. Multicollinearity

The next problem that bias regression results, as mentioned in section 4.2, is multicollinearity. Multicollinearity (Wikipedia, 2015) is the occurrence when two or more independent variables in the specifications are correlated as they try to explain similar features. Multicollinearity is one source of the bias in parameter estimates and sometimes confusing results. The table in the next page shows correlation level between variables in the specifications under the command `corr` in Stata. The values shown in the correlation matrix below are the correlation values between each variable. The higher the value or the more the value gets closer to 1 or -1 implies an almost perfect linear relationship (perfect multicollinearity) which is viewed as problematic to the regression results due to over explanation biases of independent variables. When multicollinearity is too large, the coefficients will be automatically omitted and/or the standard errors of the coefficients will be incredibly huge.

Table 6. Correlation Matrix

```
. corr lGDP lCstock lLforcePop Education Openness Hproxy1LE Hproxy3MU5 Hproxy4MI Hproxy6ASRA Hproxy2H2OR Hproxy5UHC
(obs=164)
```

	lGDP	lCstock	lLforc~p	Educat~n	Openness	Hproxy~E	Hproxy~5	Hproxy~I	Hproxy~A	Hproxy~R	Hproxy~C
lGDP	1.0000										
lCstock	0.9805	1.0000									
lLforcePop	0.6302	0.5900	1.0000								
Education	0.5352	0.5861	-0.1017	1.0000							
Openness	0.1529	0.1562	-0.6033	0.6307	1.0000						
Hproxy1LE	0.5778	0.5567	-0.0903	0.6827	0.7725	1.0000					
Hproxy3MU5	-0.7470	-0.7509	-0.1044	-0.7544	-0.6252	-0.9141	1.0000				
Hproxy4MI	-0.7321	-0.7392	-0.0742	-0.7772	-0.6471	-0.9196	0.9979	1.0000			
Hproxy6ASRA	0.5036	0.4639	-0.1672	0.6600	0.7907	0.9666	-0.8400	-0.8506	1.0000		
Hproxy2H2OR	0.7618	0.7882	0.0690	0.8162	0.6283	0.8617	-0.9524	-0.9601	0.7830	1.0000	
Hproxy5UHC	0.2579	0.2947	-0.4571	0.6436	0.7738	0.6475	-0.6488	-0.6704	0.6625	0.6527	1.0000

Since each specification in `Table 2` does not include more than one health outcomes proxy, the multicollinearity between health outcomes proxy is eliminated. What is notable here is the variable Hproxy2H2OR. By just looking at the values in the correlation matrix, it can be seen that Hproxy2H2OR is highly correlated with other health outcomes proxies (0.8617, -0.9524, -0.9601, 0.7830 with Hproxy1LE, Hproxy3MU5, Hproxy4MUI, and Hproxy6ASRA, respectively). The values are very high implying an almost perfect linear relationship between these variables and that they shouldn't be put under the same specifications. This makes more sense now looking at `Table 4` again, which shows the offsetting of significance due to high presence of multicollinearity. Therefore, it is more logical to exclude Hproxy2H2OR from specifications while including only health outcomes proxies for unbiased results.

C. Endogeneity

Another problem occurring with econometrics model is called "endogeneity". Endogeneity is also sometimes referred to as "omitted variable bias" in which there exists a cofounding factor that affects both independent variables and dependent variables. Omitted variable bias is problematic because its presence makes the causal relationship between independent variables and dependent variables obscure (Aaron, 2005). The other source of endogeneity is the reverse causality in which the relationship between variables works in both ways. This means that instead of having one-way pure effects that independent variables have on dependent variable; the effects are also reversed as the dependent variable is also the cause of the independent variable. Endogeneity again biases the regression results and make it ambiguous to observe the causal relationship using the parameter estimates.

Given this definition, I suspect endogeneity in my specifications since thinking about health and output is some kind of a reverse causality. Better health statuses can lead to higher productivity (GDP), but higher productivity can also lead to better health statuses since the country is now wealthy and can invest in quality health infrastructures resulting in better overall health statuses of population. The approach to correct for endogeneity is called overidentification test. Under overidentification test, "instrumental variables (IV)" are tested. IV are the variables the only correlate with independent/explanatory variables, in this case, the health variables, implying no correlation with the dependent variable, lGDP. Zulehner (2015) explained IV or a "Z" as a variable that is uncorrelated with the error terms but is correlated with independent variables. Using IV, the estimator will now only reflect the causal effects of dependent variable caused by the independent variable, in which is induced by IV. In order for a variable to be used as IV, two properties must be satisfied. First, the covariance of z and independent variable x must not be equal to zero; second, the covariance of z and the error term must be equal to zero.

I have attempted to find the right IV in order to test whether my models exhibit endogeneity between variables or not. Trying to find the suitable IV or a so-called overidentification test is the first approach to address endogeneity. In this case, I need to run the panel data in the form of normal OLS first by putting an assumed IV and expect no significance level from the results. If IV shows no sign of significance, I, then, need to run the same model again replace the dependent variable with the endogenous variable, along with IV, and expect a sign of significance to show correlation between IV and the endogenous variable itself. Note that the test is called overidentification test because given one endogenous variable, two or more IV must be incorporated into the models.

For a better picture, the command `reg lGDP lCstock lLforcePop Education Openness` *`EndogenousVariable InstrumentalVariable1 InstrumentalVariable2`* is the first step of finding suitable IV; in which *`EndogenousVariable`* is each of the health proxy used in the specifications above excluding the predetermined indicator of $\mathrm{Hproxy2H2OR}$ since the above specifications hasn't included this variable as the only explanatory variable in each specification, *`InstrumentalVariable1 InstrumentalVariable2`* are the two IV that are assumed to help solve endogeneity. If regression results show that both IV are not significant implying no effect on lGDP, another command is then used. The command `reg` *`EndogenousVariable`* `lCstock lLforcePop Education Openness` *`InstrumentalVariable1 InstrumentalVariable2`* is now used, but now sign of significance for both IV is expected. Admittedly, IV are very difficult to be found. Variables that can lead to better health statuses of population almost always also increase the country's GDP; therefore finding a variable that only correlates with health is very difficult (and sometimes impossible). The most common IV to think about is the lag of the explanatory variables themselves. For example, it might be that last year's life expectancy correlates with this year's life expectancy but it doesn't correlate with GDP. Having this thought in mind, I generate more variables to be used as IV which are the lagged variables of all the health proxies (ranging from one to two years). Note that _1 after the variable name indicates a lag of one period, and _2 indicates a lag of two periods. Also, some variables in the formula given above are italicized because they vary with specifications.

The specifications in `Table 2` are the first to begin with. Under fixed effects model 4, life expectancy is assumed to be endogenous in this case. I've found collectively four sets of IV, all of which include the improved water access variable. Four sets of IV are (1) Hproxy1LE_1 and Hproxy2H2OR_1 (2) Hproxy3MU5_1 and Hproxy2H2OR_1 (3) Hproxy4MI_1 and Hproxy2H2OR_1 (4) Hproxy3MU5_2 and Hproxy2H2OR_2. Each set of IV actually shows very similar results, in which they are proved to be used as IV. I'll show the regression results of (1) Hproxy1LE_1 and Hproxy2H2OR_1.

Test Results 5.1. Overidentification Test on Dependent Variable

Dependent variable: lGDP

Independent variables: lCstock, lLforcePop, Education, Openness, (Year)

Endogenous explanatory variables: Hproxy1LE

Instrumental variables: Hproxy1LE_1 and Hproxy2H2OR_1

```
. reg lGDP lCstock lLforcePop Education Openness Hproxy1LE Hproxy1LE_1 Hproxy2H2OR_1 Year
```

Source	SS	df	MS
Model	317.797606	8	39.7247008
Residual	6.62113534	147	.045041737
Total	324.418741	155	2.09302414

Number of obs =	156
F(8, 147) =	881.95
Prob > F =	0.0000
R-squared =	0.9796
Adj R-squared =	0.9785
Root MSE =	.21223

lGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lCstock	.7293151	.0444232	16.42	0.000	.6415244	.8171057
lLforcePop	.2971467	.0444074	6.69	0.000	.2093875	.384906
Education	-.0357411	.0192096	-1.86	0.065	-.0737037	.0022216
Openness	.0023322	.0006551	3.56	0.000	.0010376	.0036267
Hproxy1LE	.2315333	.1406906	1.65	0.102	-.0465041	.5095708
Hproxy1LE_1	-.2162594	.1378015	-1.57	0.119	-.4885873	.0560686
Hproxy2H2OR_1	.0023328	.0037552	0.62	0.535	-.0050885	.009754
Year	-.0022309	.0041777	-0.53	0.594	-.010487	.0060253
_cons	-.3620274	.8814192	-0.41	0.682	-2.103917	1.379863

Test Results 5.2. Overidentification Test on Endogenous Explanatory Variable

Independent variables: lCstock, lLforcePop, Education, Openness, (Year)

Endogenous explanatory variable (now used as dependent variable): Hproxy1LE

Instrumental variables: Hproxy1LE_1 and Hproxy2H2OR_1

```
. reg Hproxy1LE lCstock lLforcePop Education Openness  Hproxy1LE_1 Hproxy2H2OR_1 Year

      Source |       SS       df       MS              Number of obs =     156
-------------+------------------------------           F(  7,   148) =45783.00
       Model |  4927.48773     7  703.926818           Prob > F      =  0.0000
    Residual |  2.27554276   148  .015375289           R-squared     =  0.9995
-------------+------------------------------           Adj R-squared =  0.9995
       Total |  4929.76327   155  31.8049243           Root MSE      =    .124

------------------------------------------------------------------------------
   Hproxy1LE |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lCstock |  -.0432395   .0257101    -1.68   0.095    -.0940458    .0075667
  lLforcePop |   .0596197   .0254783     2.34   0.021     .0092715    .1099679
   Education |  -.0347892   .0108529    -3.21   0.002    -.0562359   -.0133425
    Openness |   .0022844   .0003335     6.85   0.000     .0016254    .0029434
 Hproxy1LE_1 |   .9769316   .0057869   168.82   0.000      .965496    .9883672
Hproxy2H2OR_1 |  -.0055697   .0021457    -2.60   0.010    -.0098099   -.0013294
        Year |    .013764   .0021628     6.36   0.000       .00949     .018038
       _cons |   2.212284   .4817996     4.59   0.000     1.260189    3.164379
------------------------------------------------------------------------------
```

V

As you can see, both Hproxy1LE_1 and Hproxy2H2OR_1 that are assumed to be IV show expected sign of significance in the test results. I then proceed to another step of the test (2SLS) to find whether endogeneity exists. The command is as followed

ivregress 2sls lGDP lCstock lLforcePop Education Openness (*EndogenousVariable* = *InstrumentalVariable1 InstrumentalVariable2*)

estat endogenous

estat firststage

estat overid

Test Results 5.3. 2SLS Test for Endogeneity

Dependent variable: lGDP

Independent variables: lCstock, lLforcePop, Education, Openness, (Year)

Endogenous explanatory variable: Hproxy1LE

Instrumental variables: Hproxy1LE_1 and Hproxy2H2OR_1

```
. ivregress 2sls lGDP lCstock lLforcePop Education Openness (Hproxy1LE = Hproxy1LE_1 Hproxy2H2OR_1)

Instrumental variables (2SLS) regression              Number of obs =      156
                                                       Wald chi2(5)  = 7358.23
                                                       Prob > chi2   =  0.0000
                                                       R-squared     =  0.9792
                                                       Root MSE      =  .20778
```

lGDP	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Hproxy1LE	.012365	.0070203	1.76	0.078	-.0013946	.0261246
lCstock	.7303606	.0260748	28.01	0.000	.6792549	.7814663
lLforcePop	.3028751	.035727	8.48	0.000	.2328514	.3728989
Education	-.0400473	.0148561	-2.70	0.007	-.0691648	-.0109298
Openness	.0027766	.0005386	5.16	0.000	.001721	.0038322
_cons	-.1017945	.3562385	-0.29	0.775	-.8000091	.5964201

```
Instrumented:  Hproxy1LE
Instruments:   lCstock lLforcePop Education Openness Hproxy1LE_1
               Hproxy2H2OR_1

estat endogenous

Tests of endogeneity
Ho: variables are exogenous

Durbin (score) chi2(1)          =  2.27395  (p = 0.1316)
Wu-Hausman F(1,149)             =  2.20404  (p = 0.1398)


estat firststage

First-stage regression summary statistics
```

Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	F(2,149)	Prob > F
Hproxy1LE	0.9994	0.9994	0.9967	22517	0.0000

```
Minimum eigenvalue statistic = 22517

Critical Values                      # of endogenous regressors:    1
Ho: Instruments are weak             # of excluded instruments:     2
```

	5%	10%	20%	30%
2SLS relative bias	(not available)			
	10%	**15%**	**20%**	**25%**
2SLS Size of nominal 5% Wald test	19.93	11.59	8.75	7.25
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92

```
estat overid

Tests of overidentifying restrictions:

Sargan (score) chi2(1) =  .055171  (p = 0.8143)
Basmann chi2(1)        =  .052714  (p = 0.8184)
```

As confusing as the results may seem, there are not many values to be analyzed however. The most important one is the F-statistics under `estat firststage` command. A rule of thumb according to Stock, Wright, and Yogo (2002) is that the value should be above 10 for IV to be strong enough (Berry, 2011). Having weak instruments bias the 2SLS estimator since the correlation with the endogenous variable is substantially low. The F-statistics gives the value of 22517, way higher than 10, implying strong instruments. Nevertheless, looking at the results under `estat endogenous` command, the test statistics for both Durbin and Wu-Hausman are both greater than p = 0.05 or 5%; therefore, the null hypothesis on the variables being exogenous cannot be rejected (we can only reject null hypothesis if the test statistics shows values lesser than 0.05 or designated α). In simpler words, endogeneity is not found to be presented in these specifications even after valid IV are found.

Similar results also appear under fixed effects model 5, 6, 7, and 8. For model 5, several sets of IV have been found, even with no presence of endogeneity. Seven sets of IV for under-5 mortality rates are (1) Hproxy3MU5_1 and Hproxy4MI_1 (2) Hproxy1LE_1 and Hproxy2H2OR_1 (3) Hproxy3MU5_1 and Hproxy2H2OR_1 (4) Hproxy3MU5_2 and Hproxy4MI_2 (5) Hproxy1LE_2 and Hproxy2H2OR_2 (6) Hproxy3MU5_2 and Hproxy2H2OR_2 and (7) Hproxy4MI_2 and Hproxy2H2OR_2.

Under model 6, eight sets of IV for infants' mortality rates (1) Hproxy3MU5_1 and Hproxy4MI_1 (2) Hproxy1LE_1 and Hproxy2H2OR_1 (3) Hproxy3MU5_1 and Hproxy2H2OR_1 (4) Hproxy4MI_1 and Hproxy2H2OR_1 (5) Hproxy3MU5_2 and Hproxy4MI_2 (6) Hproxy1LE_2 and Hproxy2H2OR_2 (7) Hproxy3MU5_2 and Hproxy2H2OR_2 and (8) Hproxy4MI_2 and Hproxy2H2OR_2.

For model 7, using ASRA as health proxy, no IV is found. Under model 8 which is measured by UHC, four sets of IV are found (1) Hproxy3MU5_1 and Hproxy2H2OR_1 (2) Hproxy4MI_1 and Hproxy2H2OR_1 (3) Hproxy3MU5_2 and Hproxy2H2OR_2 and (4) Hproxy4MI_2 and Hproxy2H2OR_2. I'll show the regression results for UHC using (1) Hproxy3MU5_1 and Hproxy2H2OR_1.

Test Results 6.1. Overidentification Test on Dependent Variable

Dependent variable: lGDP

Independent variables: lCstock, lLforcePop, Education, Openness, (Year)

Endogenous explanatory variables: Hproxy5UHC

Instrumental variables: Hproxy3MU5_1 and Hproxy2H2OR_1

```
. reg lGDP lCstock lLforcePop Education Openness Hproxy5UHC Hproxy3MU5_1 Hproxy2H2OR_1 Year
```

Source	SS	df	MS
Model	317.733297	8	39.7166621
Residual	6.6854449	147	.045479217
Total	324.418741	155	2.09302414

Number of obs =	156
F(8, 147) =	873.29
Prob > F =	0.0000
R-squared =	0.9794
Adj R-squared =	0.9783
Root MSE =	.21326

lGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lCstock	.6769834	.0435398	15.55	0.000	.5909387	.7630282
lLforcePop	.366594	.0467385	7.84	0.000	.2742278	.4589602
Education	-.0540418	.0174968	-3.09	0.002	-.0886196	-.019464
Openness	.003215	.0004461	7.21	0.000	.0023334	.0040967
Hproxy5UHC	.1093632	.0747383	1.46	0.146	-.0383371	.2570635
Hproxy3MU5_1	.0003477	.0018641	0.19	0.852	-.0033362	.0040316
Hproxy2H2OR_1	.0040571	.0040379	1.00	0.317	-.0039227	.0120369
Year	.0035577	.003446	1.03	0.304	-.0032525	.0103679
_cons	.7307566	.672587	1.09	0.279	-.5984322	2.059945

Test Results 6.2. Overidentification Test on Endogenous Explanatory Variable

Independent variables: lCstock, lLforcePop, Education, Openness, (Year)

Endogenous explanatory variable (now used as dependent variable): Hproxy5UHC

Instrumental variables: Hproxy3MU5_1 and Hproxy2H2OR_1

```
. reg Hproxy5UHC lCstock lLforcePop Education Openness Hproxy3MU5_1 Hproxy2H2OR_1 Year
```

Source	SS	df	MS
Model	25.4670569	7	3.63815099
Residual	8.14191745	148	.055012956
Total	33.6089744	155	.216832093

Number of obs =	156
F(7, 148) =	66.13
Prob > F =	0.0000
R-squared =	0.7577
Adj R-squared =	0.7463
Root MSE =	.23455

Hproxy5UHC	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lCstock	.2256675	.0441476	5.11	0.000	.1384264	.3129087
lLforcePop	-.3296516	.0436825	-7.55	0.000	-.4159736	-.2433296
Education	.0336333	.0190439	1.77	0.079	-.0039998	.0712664
Openness	-.0001171	.0004905	-0.24	0.812	-.0010864	.0008523
Hproxy3MU5_1	-.0087761	.0019191	-4.57	0.000	-.0125684	-.0049837
Hproxy2H2OR_1	-.0132071	.0043063	-3.07	0.003	-.0217168	-.0046974
Year	-.0096348	.0037064	-2.60	0.010	-.0169591	-.0023105
_cons	1.199093	.7331361	1.64	0.104	-.2496735	2.64786

Test Results 6.3. 2SLS Test for Endogeneity

Dependent variable: lGDP

Independent variables: lCstock, lLforcePop, Education, Openness, (Year)

Endogenous explanatory variables: Hproxy5UHC

Instrumental variables: Hproxy3MU5_1 and Hproxy2H2OR_1

```
. ivregress 2sls lGDP lCstock lLforcePop Education Openness (Hproxy5UHC = Hproxy3MU5_1 Hproxy2H2OR_1)

Instrumental variables (2SLS) regression          Number of obs =      156
                                                  Wald chi2(5)  = 7285.45
                                                  Prob > chi2   =  0.0000
                                                  R-squared     =  0.9790
                                                  Root MSE      =  .20878
```

lGDP	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Hproxy5UHC	.1303272	.1903437	0.68	0.494	-.2427396	.503394
lCstock	.7121778	.0440893	16.15	0.000	.6257644	.7985911
lLforcePop	.3574497	.0572171	6.25	0.000	.2453062	.4695931
Education	-.0419465	.0152477	-2.75	0.006	-.0718314	-.0120616
Openness	.0033564	.0004062	8.26	0.000	.0025603	.0041525
_cons	.2114719	.367644	0.58	0.565	-.5090972	.9320409

```
Instrumented:  Hproxy5UHC
Instruments:   lCstock lLforcePop Education Openness Hproxy3MU5_1
               Hproxy2H2OR_1

estat endogenous

Tests of endogeneity
Ho: variables are exogenous

Durbin (score) chi2(1)          =  .033314  (p = 0.8552)
Wu-Hausman F(1,149)             =  .031826  (p = 0.8587)


estat firststage

First-stage regression summary statistics
```

Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	F(2,149)	Prob > F
Hproxy5UHC	0.7467	0.7365	0.1238	10.5276	0.0001

```
Minimum eigenvalue statistic = 10.5276

Critical Values                        # of endogenous regressors:    1
Ho: Instruments are weak               # of excluded instruments:     2
```

	5%	10%	20%	30%
2SLS relative bias	(not available)			
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	19.93	11.59	8.75	7.25
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92

```
estat overid

Tests of overidentifying restrictions:

Sargan (score) chi2(1) =  1.24046  (p = 0.2654)
Basmann chi2(1)        =  1.19429  (p = 0.2745)
```

F-statistics is now only 10.5276, only slightly more than 10. Nevertheless, the null is still cannot be rejected, implying no presence of endogeneity. As mentioned earlier, all of these sets of IV yield very similar results so it would be very redundant to show every test result. Though many IV are found, the presence of endogeneity isn't. The last sets of specifications are from `Table 3`, model 9 to 12. We will skip specifications from `Table 4` and `Table 5` (model 13-20) since the results are biased due to the presence of multicollinearity and it wouldn't make sense to include those variables together. Many attempts have been done to find suitable IV for these sets of specifications. However, since two endogenous variables are in the same model, searching for IV that work for both endogenous variables are even more difficult. Nevertheless, no suitable IV is found for models 9 to 12.

It makes sense to find potential IV that are assumed to correlate with the explanatory variable but not with the dependent variable and still find no presence of endogeneity. Endogeneity is a very challenging concept that requires many tools to perfectly address it, thus implying one-way causality with no back and forth causation (i.e. having potential IV doesn't necessarily signify the presence of endogeneity, but IV are needed if endogeneity is presented).

VI. Conclusion

In conclusion, the purpose of this paper has been fully achieved. The relationship between health statuses and output of countries in ASEAN for 21-year period has been clearly analyzed. This paper verifies the findings of several literature reviews that the effects of health on output are prominent since healthier people can contribute to better productivity leading to higher output, ceteris paribus. The typical Cobb-Douglas production function used in macroeconomics studies that only includes physical labor and capital is therefore should be extended to include other variables that affect country's productivity. Extending the production function to include education, openness, and health variables shows the determinants of country's output in a more realistic way.

Health statuses however are measured by different proxies, each of them yields different result, slightly or sometimes significantly different from one another. Four most suitable health outcome proxies including life expectancy, under-5 mortality rates, infant mortality rates, and ASR, depending on both its relevance to the models and its availability, are used in order for an explicit comparison to be made between each measure. The powerful concept of UHC, in which governments in almost every country are trying their best to implement, along with the percentage of improved water access in a country are also another two health measures being used, though they are categorized as health input proxies rather than as health outcome proxies. After forming models, obtaining data, defining specifications, and running the regression, the results show that the effects of health on GDP in the regression don't exhibit much variation with the findings from literatures. What seems to work best is the life expectancy proxy, displaying a statistically significant 3.8% increase in GDP corresponding to a 1-year increase in life expectancy. ASR also shows a 0.32% increase, accordingly. Mortality rates are shown to be negatively correlated though not statistically significant with GDP, as less contribution is made to the productivity decreases the overall output, as predicted. Improved water access when combine with health outcome proxies, surprisingly, drops the significance of any other health variables since there is a presence of multicollinearity causing misleading results. UHC, on the contrary, shows no sign of significance in any of the models, implying that in this case UHC is not a determinant of country's output. One significant reason is that both life expectancy and ASR directly measure the average life span of the population reflecting the environment general population has been growing up in; mortality rates however reflect only up to a specified age ranges in which improvements made afterward might not be taken into account. Life expectancy and ASR then seem to be a more suitable proxy to be used in health accounting models. Given different meanings of each proxy, the regression results differ consequently.

Before being able to identify the limitations of the models, the results are biased. After correcting for the problems that usually come with panel data which includes autocorrelation, heteroskedasticity, and multicollinearity, the results are way more reliable (our focus is on Table 2 and 3). Endogeneity however, though highly suspected with successful attempts of finding potential IV, is not found to be presented. The regression results shown in Section IV are then the final results.

To sum up, this paper has shown similar results from those findings in literatures. Health is really a prominent determinant of country's overall output as measured by GDP. Improving overall health status of population generally decreases absenteeism and morbidity leading to better and higher productivity in the long run. Though some literatures pointed out the consequence of offsetting benefits resulting from an increase in population throughout the years, for simplicity and a more direct causality, I didn't take this effect into account. The models in this paper are however far from perfect, due to the unavailability of data and insufficient knowledge for more advanced forms of model, and more investigations controlling for different factors must be done to explain the impacts in a more comprehensive way. Nevertheless, the models in this paper have been used to explain the association between variables at their best capabilities.

As for policymakers who are interested in raising output of a country, I hope this research, though very slightly, contributes to your knowledge on the important determinant of country's output. Improving health statuses does help, but take note of the very long period of time. Twenty-one years are used here as a sample. However, the results might not be this promising if the sample periods are shortened. This implies that it does take long time for an improvement made in health to eventually affect output. Policymakers should be aware of this fact, since improving health might not be the suitable solution for raising immediate output. What is intriguing is that improving health statuses should be more of a humanitarian matter, though this claim is also supported economically. Health is crucial in any of the aspect especially about basic happiness and well-being. Having good health ensures no suffering from diseases or pains, making valuable contribution to each and every day. As countries are now striving toward MDGs, health becomes more and more crucial in developing well-being and sustaining growth in all aspects.

Acknowledgements

This paper won't be completed without full support and guidance from my advisor, Nopphol Witvorapong, Ph.D. Also, special thanks to Kurus Sanitwongse Na Ayudhya and Shindha Niyomthai for their helps and comments on my progress.

Appendix A

This section provides the list of every literature that has been reviewed and studied. In the literature review section, I actually present all literatures I found relevant to my topic. Some of them have been fully reviewed above, and some which are more or less irrelevant are being put here. I've classified them into three groups based on the main idea and models being covered and used.

Group 1: Solow's growth model's extensions

Authors	Titles
David N. Weil	Accounting for the Effect of Health on Economic Growth (2005)
Quamrul H. Ashraf; Ashley Lester; David N. Weil	When Does Improving Health Raise GDP? (2008)
Stephen Knowles; P. Dorian Owen	Education and Health in an Effective-Labour Empirical Growth Model (1997)

Group 1 literature used the extension of Solow's growth models. All of them included other independent variables to explain output other than physical capital and labor force. More importantly, they included health as an explanatory variable in the model. Note that every literature in this group has already been reviewed clearly in the literature review section.

Group 2: Specific models

Authors	Titles
Alok Bhargava; Dean T. Jamison; Lawrence J. Lau; Christopher J.L. Murray	Modeling the Effects of Health on Economic Growth (2001)
Jere R. Behrman; John Hoddinot; John A. Maluccio; Reynaldo Martorell	Brains versus Brawn: Labor Market Returns to Intellectual and Physical Health Human Capital in a Developing Country (2010)
Robyn Swift	The Relationship Between Health and GDP in OECD Countries in the Very Long Run (2010)
Kevin M. Murphy; Robert H. Topel	The Value of Health and Longevity (2005)

Group 2 literature similarly assessed the effects of health statuses on general population, just that their models are more specific, not a simple Solow's extension. All of them have already been reviewed, excluding *Brains versus Brawn: Labor Market Returns to Intellectual and Physical Health Human Capital in a Developing Country (2010)*. In this paper, in brief, the analysis was made on which types of health (brain or brawn) contribute to a higher return. Behrman, Hoddinot, Maluccio, and Martorell (2010) used both adult height and adult cognitive skills to measure the returns in Guatemala over 35-year period. By treating both of them as endogenous variables, their findings show that adult cognitive skills or brawns yield higher returns in labor markets. I didn't provide a thorough review for this paper since my topic doesn't take into account cognitive skills.

Group 3: Health Expenditures-Related Topics

Authors	**Titles**
Sanjeev Gupta; Marijn Verhoeven; Erwin R. Tiongson	The Effectiveness of Government Spending on Education and Health Care in Developing and Transition Economies (2002)
Pedro Pita Barros	The Black Box of Health Care Expenditure Determinants (1998)
Chunling Lu; Matthew T. Schneider; Paul Gubbins; Katherine Leach-Kemon; Dean Jamison; Christopher J. L. Murray	Public Financing of Health in Developing Countries: A Cross-National Systematic Analysis (2010)
Suzanne K. McCoskey; Thomas M. Selden	Health Care Expenditures and GDP: Panel Data Unit Root Test Results (1998)
Deon Filmer; Lant Pritchett	The Impact of Public Spending on Health: Does Money Matter? (1999)

Group 3 literatures are clearly the one dealing with health care expenditures in many countries. As mentioned earlier, I exclude health expenditures because they are more of an absolute figure which might fail to correctly reflect health statuses in a country. In *The Black Box of Health Care Expenditure Determinants,* the factors that affect the growth of health spending were analyzed for 24 OECD countries. Findings reveal that population ageing, types of health systems, and the use of physicians as gatekeepers were insignificant. The cause of the slowdown in health expenditures growth rate in the year 1980-1990 wasn't identified nevertheless. In *Public Financing of Health in Developing Countries: A Cross-National Systematic Analysis*, the paper aimed to analyze the sources for government spending on health in developing countries and assess the public financing expenditures as well as testing the correlation on change in GDP and other important factors. Results show that from 1995 to 2006, public financing of health increased by almost 100% (in US$) from domestic sources. In *The Impact of Public Spending on Health: Does Money Matter?*, the relationship between public expenditures on health and non-health factors and under-5 and infant mortality rates was being assessed. Findings show that public expenditures insignificantly affect health statuses and the variations in mortality rates were accounted more on the differences in country's income per capita, level of income distribution, extent of female education, level of ethnic fragmentation, and predominant religion.

Appendix B

This section shows the data description or the summary statistics of all the variable used in the models which are dependent variable, independent variables, and explanatory variables.

Table 7. Data Description—Summary Statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
lGDP	189	25.07	1.603	21.82	27.68
lCstock	189	26.21	1.682	23.07	28.76
lLforcePop	189	16.32	1.907	12.01	18.91
Education	189	5.869	2.018	2.690	10.63
Openness	189	130.9	94.20	10.47	440.4
Hproxy1LE	189	69.92	6.141	54.12	81.54
Hproxy2H2OR	164	74.13	22.26	19.50	100
Hproxy3MU5	189	43.76	40.11	2.800	162
Hproxy4MI	189	32.88	28.22	2.200	110.9
Hproxy5UHC	189	0.381	0.487	0	1
Hproxy6ASRA	189	826.6	64.95	656.9	939.8
Year	189	11	6.071	1	21

Appendix C

This section shows regression results under normal OLS; only the specifications in Table 2 and Table 3 will be shown. Others are available upon request. Note that under OLS method which is not preferable for panel data, regression results show that the coefficients and significance level significantly differ from those obtained under the fixed effects model.

Table 8. Regression results–one health variable at a time (excluding Hproxy2H2OR) under OLS

Dependent variable: lGDP

VARIABLES	(4) Model 4	(5) Model 5	(6) Model 6	(7) Model 7	(8) Model 8
lCstock	0.756***	0.732***	0.731***	0.763***	0.826***
	(0.0268)	(0.0313)	(0.0314)	(0.0234)	(0.0316)
lLforcePop	0.178***	0.174***	0.175***	0.187***	0.131***
	(0.0233)	(0.0249)	(0.0250)	(0.0209)	(0.0310)
Education	-0.0333**	-0.0467***	-0.0538***	-0.0438***	-0.0190
	(0.0160)	(0.0174)	(0.0178)	(0.0146)	(0.0183)
Openness	0.000434*	0.000961***	0.000922***	0.000282	0.00109***
	(0.000244)	(0.000237)	(0.000238)	(0.000221)	(0.000273)
Hproxy1LE	0.0387***				
	(0.00506)				
Hproxy3MU5		-0.00558***			
		(0.000919)			
Hproxy4MI			-0.00837***		
			(0.00138)		
Hproxy6ASRA				0.00430***	
				(0.000411)	
Hproxy5UHC					0.0896
					(0.0832)
Year	0.00214	0.00775**	0.00885***	0.00279	0.00614*
	(0.00302)	(0.00316)	(0.00319)	(0.00272)	(0.00351)
Constant	-0.228	3.356***	3.410***	-1.345***	1.152***
	(0.347)	(0.491)	(0.499)	(0.359)	(0.352)
Observations	189	189	189	189	189
R-squared	0.981	0.979	0.979	0.984	0.975

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

Table 9. Regression results—combining each proxy of health outcomes with Hproxy5UHC under OLS

Dependent variable: lGDP

VARIABLES	(9) Model 9	(10) Model 10	(11) Model 11	(12) Model 12
lCstock	0.748***	0.731***	0.731***	0.761***
	(0.0295)	(0.0331)	(0.0332)	(0.0259)
lLforcePop	0.188***	0.176***	0.176***	0.189***
	(0.0281)	(0.0294)	(0.0295)	(0.0253)
Education	-0.0346**	-0.0468***	-0.0538***	-0.0440***
	(0.0162)	(0.0175)	(0.0178)	(0.0148)
Openness	0.000386	0.000952***	0.000917***	0.000272
	(0.000256)	(0.000251)	(0.000252)	(0.000230)
Hproxy1LE	0.0384***			
	(0.00508)			
Hproxy3MU5		-0.00556***		
		(0.000936)		
Hproxy4MI			-0.00835***	
			(0.00141)	
Hproxy6ASRA				0.00430***
				(0.000414)
Hproxy5UHC	0.0471	0.00880	0.00497	0.0105
	(0.0730)	(0.0776)	(0.0777)	(0.0666)
Year	0.00260	0.00782**	0.00889***	0.00289
	(0.00310)	(0.00323)	(0.00326)	(0.00281)
Constant	-0.182	3.356***	3.409***	-1.332***
	(0.355)	(0.492)	(0.500)	(0.368)
Observations	189	189	189	189
R-squared	0.981	0.979	0.979	0.984

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

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