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HONORS THESIS

A PANEL DATA STUDY OF THE DETERMINANTS OF LIFE EXPECTANCY IN LOW INCOME COUNTRIES

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Abstract:

This study attempts to determine the impact of several socioeconomic determinants of life expectancy for 34 low income countries using ordinary least squares linear regression. Most explanatory variables were statistically significant, implying that the socioeconomic variables of interest, including government health expenditures, access to basic sanitation facilities, HIV prevalence, urbanization, education, and sex, are important measures in influencing life expectancy. Foreign aid, corruption, and undernourishment, were determined insignificant when determining life expectancy. Based on the analysis results, it has been suggested that these developing countries implement appropriate policies and programs to increase HIV education and preventative measures, increase women's rights and labor force participation, and specifically direct foreign aid inflows, in order to increase the life expectancy of people in the country.

JEL Classifications: O15, I19

Keywords: Life expectancy, economic growth, education, health care, urbanization, low income countries, foreign aid

Introduction:

Life expectancy is one of the major key indicators of population health condition and economic development in a country. In most countries of the world, life expectancy at birth has increased over the last decade. It can fall due to tragedies such as famine, war, disease and poor health. Improvements in areas such as health and welfare can increase life expectancy (Hossain, 2013). Previous studies have demonstrated that health condition leads to economic growth. The study by Acemoglu and Johnson (2007), demonstrated the relationship between increased life expectancy and improvement in economic growth (measured through Gross Domestic Product (GDP)/capita)), controlling for country fixed effects. The researcher's estimations provide evidence of a positive relationship between life expectancy and GDP per capita, indicating that countries with greater declines in mortality may have a slight increase in GDP per capita.

The relationships of life expectancy on economic growth have been well established at the individual level in earlier research. From a theoretical perception, there are multiple channels through which life expectancy affects economic growth. Firstly, healthier individuals increase their incomes by being more productive, physically more energetic and mentally more robust. A second mechanism for improved economic development is through increases in savings. As people live longer, they will tend to invest more in their retirement. For example, a 10-year increase in longevity is shown to lead to a 4.5% rise in savings (Bloom, Canning and Sevilla, 2004). Thirdly, the improved health status of the people can lead to increased economic growth through increase in education levels. Healthier people tend to invest more in their skills in order to earn higher wages than less healthy people. In addition, a healthier child can attend school, learn more and have higher cognition.

Not only does increased health, resulting in increased life expectancy, expand growth domestically, but it also impacts international relations. Life expectancy, as the strongest indicator of healthiness of a population, is a proxy for human well-being. The World Health Organization's Report of the Commission on Macroeconomics and Health asserts: ''a healthy workforce is important when attracting foreign direct investment (FDI)'' (Commission on Macroeconomics and Health, 2001). Many international agencies have made similar statements regarding the effect of health on FDI inflows. Such claims have bolstered the position of health

on the global development agenda. If health increases FDI inflows in low income countries, then targeting life expectancy could be utilized as a strategy to increase economic growth. Therefore, developing nations interested in increasing long-term economic growth, should also be interested in increasing life expectancy in the country.

One of the oldest debates involving economic development in low-income nations is the effectiveness of foreign aid in reducing poverty. This debate has continued for over 50 years and is still just as heavily argued as it was when it started (McGillivray et al. 2006). In spite of all that has been written, both academics and policy makers continue to disagree about the merits of overseas aid programs as a means of overcoming the impoverishment of many countries around the world and alleviating the struggles of millions of people. This lack of consensus is due largely to the contradicting results of previous empirical studies which have failed to produce robust evidence that may resolve the issue one way or the other. Proponents of foreign aid, while recognizing its limitations, contend that it has done much to promote growth and raise living standards, and that the outcome for many countries would have been a great deal worse without it (Sachs, 2005). It is further argued that the reason why aid programs may have failed on occasions is not that they lacked potential to improve economic performance, but rather that they were simply insufficient. This view is encapsulated in the big push approach to economic development - that is, the proposal to inject low-income countries with substantial amounts of funds in order to enable them to escape from the poverty trap equilibrium into which they have fallen. Critics of this approach claim that it is misguided, as there is no evidence to suggest that foreign aid has been instrumental in fostering growth and development. On the contrary, it is argued that three decades of overseas assistance have done little or nothing to alleviate poverty, but have merely encouraged corruption and helped to keep bad governments in power (Easterly, 2006a).

This paper attempts to evaluate the overall effectiveness of foreign aid in terms of its historical impact on life expectancy. If life expectancy is the best measurement of well-being, then the relationship between international assistance and life expectancy can be used to determine the success or failure of international aide. Is it helping the people of these developing nations at all? If it is determined to not be very effective, is there a way that international assistance can be

better directed, for example, directly funding private healthcare or improving sanitation services? This paper will attempt to understand the relationship between life expectancy and foreign aid, and to make suggestions on future aid programs.

This study will empirically analyze the determinants of life expectancy in low income nations from 2005 to 2015. Life expectancy will serve as an indicator of the health of a population and proxy for human welfare. Many studies suggest that increased life expectancy leads to long-term economic growth. This may be due in part to the positive relationship between life expectancy and foreign direct investment. Alsan, Bloom, and Canning (2006) conclude that "raising life expectancy by one year increases gross Foreign Direct Investment (FDI) inflows by nine percent (9%), after controlling for other relevant variables." These findings are consistent with the popular view that health is an integral component of human capital for developing countries. A better understanding of what factors are important in determining life expectancy could in-turn be targeted as factors promoting economic growth. The objectives of this study are to determine what variables contribute to life expectancy in developing nations, and how international assistance can be better directed in order to increase it. Blackburn and Forgues-Puccio (2011) question whether or not international assistance is a waste of capital, only aiding in corruption, or if it actually succeeds in assisting the receiving nation's population. If life expectancy is the best measurement of well-being, then the relationship between international assistance and life expectancy could be used to determine the success or failure of international aide.

This study contributes significantly to the literature by focusing on the links between life expectancy, international aid, and economic growth. Typically, aid is compared with economic growth, but they do not focus on the relationship between international aid and life expectancy. It is important to examine multiple factors of life expectancy in combination with international aid in order to determine which factors are more effective in increasing life expectancy. Not only is it crucial for developed nations to direct international assistance in a way that is not profligate of resources, but there is arguably a moral obligation to increase the well-being of all human life, including those people of underdeveloped nations whom are struggling economically.

Background:

While typically assumed strictly exogenous for the purpose of policy analysis, it has been argued that life expectancy (or more broadly "health") is predetermined by behavioral and policy variables in what can be loosely described as a production function for health. Estimating this function is the goal of this study. Auster, Leveson, and Sarachek (1969) were the first economists to study a population production function for health: a regression of state-level mortality rates on medical care and environmental variables. If societal health can be measured as life expectancy or mortality rates, what are the various socioeconomic factors that increase or decrease it? Which of these factors produces the largest health benefits to society? Many macroeconomic studies show that several factors contribute to overall health status. Most of these have used aggregate data from the member countries of the OECD (Organization for Economic Cooperation and Development) to explain cross-country life expectancies. While the empirical results are mixed, the general consensus is that population life expectancy is a function of environmental measures, lifestyle measures, and health care measures (Shaw, Horrace, Vogel, 2005). These factors include socioeconomic development, education, culture, environment, health expenditures, urbanization, gender and life style. The World Health Organization has previously established the differences in OECD and developing nations regarding health and mortality (World Health Organization 2010). For that reason, this study will analyze the impact of environmental, lifestyle, and health measures in developing nations in order to understand which factors have the strongest benefits for developing societies. This study uses a modified version of a model adapted from Bayati et al. (2013).

Ultimately, the goal of this study is to predict the production function for health as measured by life expectancy. Therefore, the primary model was characterized as: H= F (E,S,En). Health status (H) was determined by economic (E), social (S), and environmental (En) factors. Different variables have been used to explain health status. Education is an important factor that determines health in several ways (Kabir 2008). People with high education are more likely to have better jobs, higher incomes, and lower risky behaviors. Food quality and quantity are central to health promotion. Shortage of food and excess intake both contribute to several health problems. Food has been considered in some studies as an input of the health production

function. Health expenditure, as representative of resources allocated to health care, shows the access of people to health care production facilities. Previously, it has been considered for explaining the health status of the society (Heijink et al., 2013) but the relationship between expenditures and life expectancy is highly debated. Urbanization is another determinant of health which can have both positive (increasing access to medical centers and information) and negative (pollution) impacts on the overall health. Other factors such as pharmaceutical expenditures, life style, pollution, income inequality, and crime rate have been mentioned as determinants of health. The variables for this study will be discussed further in the data and variables section.

This study extends previous literature in two ways. First, it provides a better understanding of the overall determinants of health in low income economies versus just OECD or developed nations. Second, the current study uses panel data tracing 34 low income countries over ten years (2005-2015), which provides results with less bias and better estimation and normality in comparison to time series and cross sectional data studies. The current study attempts to understand the variables used in past research to analyze the ways in which life expectancy is influenced most. This study focuses on low-income economies which are proven to be impacted differently than developed nations in past studies. In a globalizing economy it is important to understand and maintain productive and efficient human capital in order to keep longer term growth alive. A major factor contributing to the development and health of low-income nations is that of international foreign aid. This study will attempt to use the impact of aid on life expectancy as a clue into whether or not foreign aid is successful in improving the lives of the people in these countries. Many studies have been done in similar regards, but usually aid effectiveness is looked at separately from the determinants of life expectancy. Typically, aid is compared with economic growth or life expectancy in general, but never takes into account other factors. It is important to examine multiple factors of life expectancy and international aid so that we can determine which factors are more effective in increasing life expectancy. This will allow estimation of the influence of many factors including aid on life expectancy, in order to suggest future ways of directing international assistance or domestic attention to increase well-being and economic growth.

Empirical Framework:

Method

Most studies on life expectancy use a linear regression model. This study also applies ordinary least squares linear regression. Ordinary least-squares (OLS) regression is a generalized linear modelling technique that may be used to model a single response variable which has been recorded on at least an interval scale. The technique may be applied to single or multiple explanatory variables and also categorical explanatory variables that have been appropriately coded (Hutcheson 2011). This model will predict the relationship between a continuous response variable and a continuous explanatory variable, where the response variable is predicted by the explanatory variable. The user of regression analysis attempts to discern the relationship between a dependent variable (ie. life expectancy) and one or more independent variables (ie. determinants of life expectancy). That relationship will not be a functional relationship, however, nor can a cause-and-effect relationship necessarily be inferred. OLS regression is particularly powerful as it relatively easy to also check the model assumptions such as linearity, constant variance and the effect of outliers using simple graphical methods.

Most statistical tests rely on certain assumptions about the variables used in the analysis. When these assumptions are not met the results may not be trustworthy, resulting in a Type I or Type II error, or over- or under-estimation of significance or effect size(s). For linear regression there are a few assumptions that must be met in order to consider the test accurate and reliable. Variables should be normally distributed. Outliers can be identified either through visual inspection of histograms or frequency distributions, or by converting data to z-scores (Osborne and Waters, 2002). Analyses by Osborne (2001) show that removal of univariate and bivariate outliers can reduce the probability of Type I and Type II errors, and improve accuracy of estimates. Second, assumption of a linear relationship between the independent and dependent variables. Standard multiple regression can only accurately estimate the relationship between dependent and independent variables if the relationships are linear in nature. As there are many instances in the social sciences where non-linear relationships occur, it is essential to examine analyses for non-linearity. If the relationship between independent variables (IV) and the dependent variable (DV) is not linear, the results of the regression analysis will under-estimate the true relationship. This

under-estimation carries two risks: increased chance of a Type II error for that IV, and in the case of multiple regression, an increased risk of Type I errors (over-estimation) for other IVs that share variance with that IV. Authors such as Pedhazur (1997), Cohen and Cohen (1983), and Berry and Feldman (1985) suggest three primary ways to detect non-linearity. A preferable method of detection is examination of residual plots. Another assumption is that of homoscedasticity. Homoscedasticity means that the variance of errors is the same across all levels of the IV. When the variance of errors differs at different values of the IV, heteroscedasticity is indicated. According to Berry and Feldman (1985) and Tabachnick and Fidell (1996), slight heteroscedasticity has little effect on significance tests; however, when heteroscedasticity is marked it can lead to serious distortion of findings and seriously weaken the analysis thus increasing the possibility of a Type I error. This assumption can be checked by visual examination of a plot of the standardized residuals (the errors) by the regression standardized predicted value. All of these assumptions will be verified in the statistical testing section.

Data and Variables

The linear regression model was applied to a panel data set. This analyzed 34 low income countries over the 10-year span 2005-2015. In panel data method, the same cross-sectional unit (say a family or a firm or a state) is surveyed over time (Gujarati, 2004). The standard panel data form can be presented as below:

$y_{it} = x'_{it}\beta + \alpha_{it} + \varepsilon_{it} = x'_{it}\beta + u_{it}$ $i = 1, 2, \ldots, N$ $t = 1,2, \ldots, T$ (1) Where, y and x' denote the dependent variable and K×1 regressor vector respectively. β is a K×1 vector of coefficient and u indicates the error term. The number of cross sectional observations is N and these units are repeatedly measured. This is the conventional panel data model defined by an unobserved individual effect and time varying coefficients. Many previous studies have involved life expectancy. The majority of these studies analyzed panel data for developed countries, such as the US (Lichternberg, 2000), Canada (Crémieux et al., 2005) or the OECD countries (Hitiris and Posnet, 1992), though some recent papers are focused on developing and less developed countries (Bayati et al., 2013). Panel data is used in order to minimize the effect of outliers and to normalize the distribution of the data.

In this study, the explanatory variables were selected based on the literature and data availability for low income countries (Stahl 2004.). The variables representing the economic factors were limited to health expenditures, nourishment, corruption index (relative to this studies interest in foreign aid) and access to sanitation facilities. This study is highly focused on the role that international aid plays on life expectancy and well-being in developing nations, thus aid inflows has also been added to this section. Additionally, the variables representing social factors were limited to education, gender and HIV prevalence. Finally, the variables representing the environmental factors included urbanization and carbon dioxide emissions per capita. Ultimately,

LE= f (HE,FD,CPIA,SAN,AID,EDU,HIV,URB,CO2,SEX) was the final equation.

LE: Life expectancy at birth, total (in years). It indicates the number of years a newborn would live if historical patterns of mortality at the time of birth were to remain consistent throughout the lifespan. Life expectancy measures health and mortality. It is recorded annually. Limitations and exceptions: Annual data from United Nations Population Division's World Population Prospects include data from 5 year periods. Therefore, they may not reflect real events as much as observed data. (World Development Indicators).

HE: Current health expenditures (% of GDP). Estimates of current health expenditures include healthcare goods and services consumed during each year. This indicator does not include capital health expenditures such as buildings, machinery, IT, etc. Limitations and exceptions: The World Health Organization (WHO) has revised health expenditure data using the new international classification for health expenditures in the revised System of Health Accounts (SHA 2011). WHO's Global Health Expenditure Database in this new version is the reference source for health expenditure for international comparison imbedded in a standardized framework. The SHA 2011 clarifies the financing mechanisms and introduces new dimensions which improve the comparability of health expenditures in the perspective of universal health coverage. (World Development Indicators). Expected relationship: positive.

FD: Prevalence of undernourishment (% of population). Population below minimum level of dietary energy consumption (also referred to as prevalence of undernourishment) shows the percentage of the population whose food intake is insufficient to meet dietary energy

requirements continuously. Data showing as 5 may signify a prevalence of undernourishment below 5%. Limitations and exceptions: First, food insecurity exists even where food availability is not a problem because of inadequate access of poor households to food. Second, food insecurity is an individual or household phenomenon, and the average food available to each person, even corrected for possible effects of low income, is not a good predictor of food insecurity among the population. And third, nutrition security is determined not only by food security but also by the quality of care of mothers and children and the quality of the household's health environment (Smith and Haddad 2000). (World Development Indicators). Expected relationship: negative.

CPIA: CPIA transparency, accountability, and corruption in the public sector rating (1=low to 6=high). Transparency, accountability, and corruption in the public sector assess the extent to which the executive can be held accountable for its use of funds and for the results of its actions by the electorate and by the legislature and judiciary, and the extent to which public employees within the executive are required to account for administrative decisions, use of resources, and results obtained. The three main dimensions assessed here are the accountability of the executive to oversight institutions and of public employees for their performance, access of civil society to information on public affairs, and state capture by narrow vested interests. Limitations and exceptions: The CPIA exercise is intended to capture the quality of a country's policies and institutional arrangements, focusing on key elements that are within the country's control, rather than on outcomes (such as economic growth rates) that are influenced by events beyond the country's control. More specifically, the CPIA measures the extent to which a country's policy and institutional framework supports sustainable growth and poverty reduction and, consequently, the effective use of development assistance. (World Development Indicators). Expected relationship: negative.

SAN: People using at least basic sanitation services (% of population). The percentage of people using at least basic sanitation services, that is, improved sanitation facilities that are not shared with other households. This indicator encompasses both people using basic sanitation services as well as those using safely managed sanitation services. Improved sanitation facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved

pit latrines, compositing toilets or pit latrines with slabs. Limitations and exceptions: National, regional and income group estimates are made when data are available for at least 50 percent of the population. (World Development Indicators). Expected relationship: positive.

AID: Net official development assistance and official aid received (constant 2015 US$). Net official development assistance (ODA) consists of disbursements of loans made on concessional terms (net of repayments of principal) and grants by official agencies of the members of the Development Assistance Committee (DAC), by multilateral institutions, and by non-DAC countries to promote economic development and welfare in countries and territories in the DAC list of ODA recipients. It includes loans with a grant element of at least 25 percent (calculated at a rate of discount of 10 percent). Net official aid refers to aid flows (net of repayments) from official donors to countries and territories in part II of the DAC list of recipients: more advanced countries of Central and Eastern Europe, the countries of the former Soviet Union, and certain advanced developing countries and territories. Official aid is provided under terms and conditions similar to those for ODA. Part II of the DAC List was abolished in 2005. The collection of data on official aid and other resource flows to Part II countries ended with 2004 data. Data are in constant 2015 U.S. dollars. Limitations and exceptions: Some low income countries included in this study may not be considered an official ODA recipient. Conversely, aid may be received from a country who is not considered an official DAC country. (World Development Indicators). Expected relationship: positive.

EDU: Literacy rate, adult total (% of people ages 15 and above). Adult literacy rate is the percentage of people ages 15 and above who can both read and write with understanding a short simple statement about their everyday life. Literacy rate is an outcome indicator to evaluate educational attainment. This data can predict the quality of future labor force and can be used in ensuring policies for life skills for men and women. It can be also used as a proxy instrument to see the effectiveness of education system; a high literacy rate suggests the capacity of an education system to provide a large population with opportunities to acquire literacy skills. The accumulated achievement of education is fundamental for further intellectual growth and social and economic development, although it doesn't necessarily ensure the quality of education. Limitations and exceptions: In practice, literacy is difficult to measure. Estimating literacy rates

requires census or survey measurements under controlled conditions. Many countries report the number of literate people from self-reported data. Some use educational attainment data as a proxy but apply different lengths of school attendance or levels of completion. There is a trend among recent national and international surveys toward using a direct reading test of literacy skills. Because definitions and methods of data collection differ across countries, data should be used cautiously. (World Development Indicators). Expected relationship: positive.

HIV: Prevalence of HIV, total (% of population ages 15-49). Prevalence of HIV refers to the percentage of people ages 15-49 who are infected with HIV. Limitations and exceptions: The limited availability of data on health status is a major constraint in assessing the health situation in developing countries. Surveillance data are lacking for many major public health concerns. Estimates of prevalence and incidence are available for some diseases but are often unreliable and incomplete. National health authorities differ widely in capacity and willingness to collect or report information. (World Development Indicators). Expected relationship: negative.

URB: Urban population (% of total). Urban population refers to people living in urban areas as defined by national statistical offices. The data are collected and smoothed by United Nations Population Division. Explosive growth of cities globally signifies the demographic transition from rural to urban, and is associated with shifts from an agriculture-based economy to mass industry, technology, and service. In principle, cities offer a more favorable setting for the resolution of social and environmental problems than rural areas. Cities generate jobs and income, and deliver education, health care and other services. Cities also present opportunities for social mobilization and women's empowerment. Limitations and exceptions: Aggregation of urban and rural population may not add up to total population because of different country coverage. There is no consistent and universally accepted standard for distinguishing urban from rural areas, in part because of the wide variety of situations across countries. Most countries use an urban classification related to the size or characteristics of settlements. Some define urban areas based on the presence of certain infrastructure and services. And other countries designate urban areas based on administrative arrangements. Because of national differences in the characteristics that distinguish urban from rural areas, the distinction between urban and rural

population is not amenable to a single definition that would be applicable to all countries. (World Development Indicators). Expected relationship: positive.

CO2: CO2 emissions (metric tons per capita). Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. Limitations and exceptions: Although estimates of global carbon dioxide emissions are probably accurate within 10 percent (as calculated from global average fuel chemistry and use), country estimates may have larger error bounds. Trends estimated from a consistent time series tend to be more accurate than individual values. Each year the CDIAC recalculates the entire time series since 1949, incorporating recent findings and corrections. Estimates exclude fuels supplied to ships and aircraft in international transport because of the difficulty of apportioning the fuels among benefiting countries. (World Development Indicators). Expected relationship: negative.

SEX: Sex was taken into consideration by breaking life expectancy (LE) down into male and female. Each country and year has two data points, one for female life expectancy and one for males. Since they are within the same country, all other variables are identical, except for this sex variable. Thus, this variable coefficient only captures the difference between life expectancy for males and females in the same country.

See Appendix A for a definition of variables and expected relationship to life expectancy.

Econometrics Model:

The following econometrics model was developed:

$LE_{it} = \beta_{0it} + \beta_1 HEit + \beta_2 FD_{it} + \beta_3 CPIA_{it} + \beta_4 SAN_{it} + \beta_5 lAID_{it} + \beta_6 EDU_{it} + \beta_7 HIV_{it} + \beta_8 URB_{it} + \beta_9 CO2_{it} + \beta_{10} SEX_{it} + u_{it}$. U is the error term with classical assumptions. Country and time period are shown by i and t, respectively. Because foreign aid has such a wide distribution with very large numbers, the variable is being presented in log form. The beta coefficient of AID represents the change in LE according to a 1% change in the corresponding independent variable.

Data Collection:

This study utilized data that was gathered from World Development Indicators. World Development Indicators, also referred to as WDI, is "the primary World Bank collection of development indicators, compiled from officially-recognized international sources. It presents the most current and accurate global development data available, and includes national, regional and global estimates" (World Development Indicators 2018). Since the WDI is a large database with all the available data, this was the only quantitative source utilized in this study.

Annually, the World Bank revises the analytical classification of the world's economies based on the gross national income (GNI) per capita estimates from the previous year. As of this year, low income economies are countries with a GNI per capita of $1,025 or less (World Bank Data Team). Therefore, this study will be analyzing low income countries as defined by the World Bank. First, each country/year (ie. Cambodia 2017) was considered one data sample. Samples with missing data were removed. Significant outliers over or under 20% of the average, were considered inaccurate collections and were omitted as well. This was to comply with the ethical considerations discussed. There were no modifications of the data, including estimating missing data nor any attempts to improve speculative discrepancies.

See Appendix G for a list of all countries used in the study.

Statistical Testing Modeling:

In order to run a linear regression model, there are underlying assumptions that need to be met as aforementioned. In order to comply with these assumptions, the following tests were run: multi-collinearity, correlation, and homoscedasticity. From there, a linear regression could be run. Because this is a panel data study, there was a possibility of serial correlation which was tested for as well. T-tests for significance of individual variables was ran along with an F-test to test whether or not the variables are significant in the population together as a model. SAS Enterprise Guide software was used to run all statistical and analytical tests. The results of these tests can be found in the regression results section.

Results:

Descriptive Statistics:

For low income nations as defined by the World Bank, the average life expectancy at birth was 58.89 years between 2005 and 2015 with a minimum of 42.55 and a maximum of 77.05. Health expenditures average 6.30% of GDP with a maximum of 19.73% and a standard deviation of 2.5%. Prevalence of undernourishment in these 34 nations averaged 27.44% of population with the maximum being as high as 58.6% of population being considered undernourished. CPIA averaged 2.60 on a scale of 1 to 6. The maximum was 3.5 out of 6. Percent of population using at least basic sanitation services averages 30.5% of population with a standard deviation of 22.83 and a maximum of 95.49% of people having access to basic sanitation services. Aid was logged in order to minimize the variance and standardize the data more easily. Log of aid averaged 20.12 with a small standard deviation of 1.13. HIV prevalence averaged 3.03% of population with a minimum of 0.1% of population and a maximum of 18.5% of population. Urbanization averaged 32.50% of population living in rural areas in these low income nations, reaching a maximum of 61.28%. Carbon dioxide emissions averaged 0.35 metric tons per person. Literacy rates (EDU) averaged 50.2% of population being considered literate with a minimum of 15.5% and a maximum of 99.998% of the adult population being literate. Descriptive statistics for the variables can be found in appendix B.

Regression Results:

Initial tests were run on the data as a whole to ensure there were no complications with the data and that an ordinary least squares regression could be run on the data set. Appendix C shows the collinearity diagnostics. There are 11 variables that the collinearity diagnostics analyze. None of the variables in this model have eigenvalues close to zero corresponding to extremely high condition indexes. No multicollinearity existed in this data set. Appendix D is the test of first and second moment specification. This test analyzes data for heteroscedasticity. The chi-square value is insignificant which verifies the homoscedasticity assumption. Thirdly, Appendix E represents a test for serial correlation which could be present due to the panel data set. The Durbin-Watson statistic of 1.86 indicates that there is no serial correlation in this model. These three test results

allow for linear regression to be run on the data without manipulation. The model's F-statistic was significant, indicating that the model's variables are significant in combination with each other. Moreover, the r-squared value was 75.48, indicating that over 75% of the variation in life expectancy was predicted by changes in the independent variables.

The regression outputs can be found in Appendix F. HE, SAN, HIV, URB, EDU, and SEX were all significant at the 1% level, as they all have p values less than 0.01. CO2 had a p value of 0.0108, so it is significant as well. FD, CPIA, and logAID had p values of 0.3843, 0.3150, and 0.1375 respectively. Therefore, these three variables were determined to be insignificant. HE, FD, CPIA, HIV, and URB were all inversely related to life expectancy in this model. CO2, SAN, EDU, SEX, and AID had positive relationships with life expectancy. The table in Appendix F shows the coefficients of each of the variables. The coefficients determine the magnitude of the relationship between each variable and life expectancy. The variables will be discussed further in the discussion section of the working paper.

Discussion:

This study estimated a health production function in three factors: economic, social, and environmental. Economic factors used were health expenditures, nourishment, corruption index, access to sanitation facilities, and foreign aid. Except for SAN and AID, the economic factors showed inverse relationships with life expectancy.

Health expenditures has typically been known to show a positive relationship with life expectancy. This intuitively makes sense that as the government spends money and allocates resources to health care, life expectancy should increase. Some studies however, have resulted in negative relationships. It is believed that the high expenditures on health in low income areas are related to high user fee; thus, the positive effects of health facility provision due to increment expending in health is offset by reduction of personal financial access. Thus, the negative result in this study is exemplified as it only analyzes low income countries. In addition, population may be increasing faster than GDP in these countries, so even though countries are allocating more of their resources towards health expenditures, it proportionally is decreasing compared to population. As health expenditures increase by 1% of GDP, life expectancy decreases by 0.62

years, significantly. This indicates that increased health expenditures are not the best allocation of resources in attempting to increase well-being and further, economic growth.

In this study, undernourishment was determined insignificant in aiding in life expectancy. This is attributed to the fact that there are more important aspects of life that contribute to life expectancy other than undernourishment. For example, a significant variable such as percent of people using basic sanitation services, is more important than nourishment when it comes to longevity.

The second variable determined to be insignificant was CPIA. Previous studies indicate that while corruption is detrimental to economic growth, and certainly negatively associated with life expectancy, it does not play a significant role. The coefficient associated with the variable was also low, at 0.76. Meaning, that as the CPIA rating decreased by 1, life expectancy would increase by less than a year. Since CPIA is only on a scale of 1 to 6, it is very hard to reduce CPIA by an entire point, and overall, completely eliminating corruption, an impossible feat, would only increase life expectancy by 4 years. A lower level of corruption or a better control of corruption in a country can lead to longer life expectancy, a lower infant mortality rate and a lower under-five mortality rate for citizens. However, previous studies find no significant association between corruption and individual diseases including human immunodeficiency virus prevalence. This will be discussed further later in the paper. This finding suggests that corruption reduction itself is not an effective method to promote health, but that when combined with other more significant methods, it can improve life expectancy overall.

SAN was found to be a very significant variable, but as the percent of people using at least basic sanitation services increased by 1%, life expectancy only increased by 0.13 years. There are two possible reasons for this. The first, is that basic sanitation services are not advanced enough to eliminate the threat that public defecation presents, or, over the past several years, the percent of people using these services has not changed enough to determine a strong enough relationship. This could be studied in the future, by utilizing a variable that measures percent of people utilizing advanced sanitation services instead of basic services.

It is interesting to note that while foreign aid had a positive impact on life expectancy, it was determined to be insignificant. Previous studies analyzing the link between life expectancy and foreign aid have determined that foreign aid just increases internal corruption, and that the capital is not being spent in ways that can actually enhance the well-being of the citizens of the country. This is evident as aid was deemed insignificant in comparison to the other variables used in this study such as sanitation services. This is important to note because billions of dollars each year are sent to underdeveloped nations in an attempt to aid in the well-being of citizens, in addition to rescuing their financial and economic situations. However, this capital is not having enough of an effect to be classified as a useful allocation of resources. The aid most likely needs to be directed in specific ways in order to be more useful and have more of an impact on longevity and less of an impact on corruption. It is also possible that the aid is not having an impact on longevity because although aid increases every year, so does population in these countries. Aid received may need to be more proportionate to population, but it may also just increase corruption further.

The variables representing social factors were education, gender and HIV prevalence.

The results of education expected from the literature review were verified. In general, individuals with higher levels of education have higher sensitivity and awareness about their health; therefore, they took more actions to improve the quantity and quality of their health. Thus, as literacy rates increase by 1%, life expectancy increased by 0.17. This was not a variable of large magnitude, however. This is possibly because a lot of the countries have high literacy rates in general. It could also be because due to misclassification of "literacy". Some countries may report differently, or classify the term differently. Future studies could use a variable such as secondary or tertiary education levels to detect a larger magnitude of the positive relationship between health and education.

In addition, the gender variable reported that females live on average 2.62 years longer than men in these countries. This is extremely important as many women in these countries do not have many rights. They are not afforded the same freedom and liberties as men. A huge portion of this is their under involvement in the labor force. If women are living longer than men, they have more time to develop their education and contribute their productivity to the environment.

Focusing on increasing women's rights and labor force participation in these economically developing countries could aid in their success in development.

HIV had a negative relationship as expected, but it was one of the top three largest, most significant variable in the study, with a coefficient of -0.80. This is due to the deadliness of HIV and its extreme prevalence in these nations, especially Africa. As prevalence of a deadly disease decreases, population health and overall longevity will increase. This is consistent with other studies, however, this is still a crucial finding. When combined with all of the other variables in this study, HIV stands out significantly. This helps conclude that a very effective way of increasing life expectancy, and consequentially economic development in low income countries, is to reduce the prevalence of HIV. Thus, education on the topic and preventative measures must increase.

Finally, the variables representing the environmental factors included urbanization and carbon dioxide emissions per capita. In the current study, CO2 emissions were expected to have a negative impact on health. However, that was not the case of the results. CO2 had a very large and significant impact on LE. Past studies indicate this is because increased CO2 levels indicate development and urbanization of countries. When nations are developing this way, it is typically increasing employment and production, which is aiding in the success of the country and increasing the life expectancy of people. What is interesting however, is that urbanization had a negative impact on life expectancy. In past studies, this result was attributed to the possibility that people saw the positive effects of living in urbanized areas, (increased access to health information, medical services, etc.), and started overcrowding the areas, which negated the positive effects the urban areas were once seeing.

Conclusion:

The main conclusions of this study have some policy implications. First, foreign aid needs to be specifically targeted towards struggling sectors of a country. Otherwise, it is not significant in its goal of having a positive impact on overall well-being, which is most widely measured by life expectancy. Thus, developed nations are just aimlessly throwing excess capital at these developing countries without any positive effects. They are ultimately just increasing corruption which is detrimental to the economy as a whole in the long run. It may also be that aid needs to be much more significant because of population growth in these countries. In addition, developing countries looking to increase their life expectancy and economic growth, need to focus more on women. Enhancing women's quality of life, including but not limited to increasing their freedom and labor force participation, will significantly impact a countries growth. If women are able to live longer on average, ceteris paribus, then educating and employing females can provide a longer return on investment. Finally, HIV is extremely important in saving underdeveloped nations from falling victim the endless poverty gap. It is crucial that these nations reduce the prevalence of HIV and its deadliness. This can be achieved through increased preventative measures, increased education on the topic of HIV, and even increased efforts towards a cure. Although certain variables, such as undernourishment and corruption reduction are undoubtedly important for well-being, they may not necessarily be important for increasing life expectancy compared to other methods.

The conclusions of this study are not without limitations. Limitations include the limited scope of the variables. This study is unable to recognize the complex construction of each country and their individualized healthcare for example. The study estimated a health production function for low income countries in general. Therefore, providing evidence for a single country, will require an estimate of the function separately for the individual country. These results are what is evident in the present investigation using cross-country, panel data. Of course, analyses of panel data for a considerable period of time for selected countries would demonstrate different results, but unavailability of long-term data for relevant indicators is a particular problem. Another limitation includes the possible misclassification of variables and their discrepancies in reporting as mentioned in the discussion above. Upon further review, Health expenditures may have been

changed to per capita instead of percent of GDP. This study sought to understand that if a country focuses more of their capital on healthcare, including development, then how would it affect life expectancy. It may be different if it was calculated per capita because over time population has increased, and it may not be in proportion with the increase in GDP. Similarly, net official aid received may be looked at in relation to aid per capita. This study understands that developed nations sending aid to other countries send what they can, thus it was looked at as a whole instead of per capita. However, it may be interesting to see the relationship between aid per capita and to understand that aid may be significant when compared to population. Finally, a limitation to this study comes from the lack of range of data for certain variables. For example, percent of people using at least basic sanitation services hardly changes annually, thus even though a 15-year spread was used, there was not enough variation in the data points to determine a significantly large relationship.

Future studies may investigate the relationship between urbanization, CO2 emissions, and life expectancy, since there were discrepancies in their relationships. In addition, they may specifically look into how to make foreign aid more impactful since this study just determined its insignificance. In addition, some of the variables used to predict the health function may be changed to account for different issues found in the data as mentioned above. For example, instead of literacy rates used to represent education, studies may use completion of secondary schooling. These simple changes may reduce some of the limitations of this study. Future studies should also wait several years in order to have a longer history of the variables and thus more data points.

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Appendices:

Appendix A - Variable Description

Variable Abbreviation	Description of Variable	Expected Relationship
LE	Life expectancy at birth, total (in years)	--
HE	Current health expenditures (% of GDP).	Positive
FD	Prevalence of undernourishment (% of population).	Negative
CPIA	CPIA transparency, accountability, and corruption in the public sector rating (1=low to 6=high).	Negative
SAN	People using at least basic sanitation services (% of population).	Positive
AID	Net official development assistance and official aid received (constant 2015 US$).	Positive
HIV	Prevalence of HIV, total (% of population ages 15-49).	Negative
URB	Urban population (% of total).	Positive
CO2	CO2 emissions (metric tons per capita)	Negative
EDU	Literacy rate, adult total (% of people ages 15 and above).	Positive
SEX	Captures the difference between life expectancy for males and females in the same country	--

Appendix B – Summary Statistics

Variable	Me
LE	58.8927(
HE	6.3016
FD	27.4474

Appendix C – Collinearity Diagnostics

HIV	1	-0.81727	0.10183
URB	1	-0.11303	0.03541
CO2	1	5.81725	1.85801
EDU	1	0.16355	0.02270
Sex1	1	2.62402	0.53410

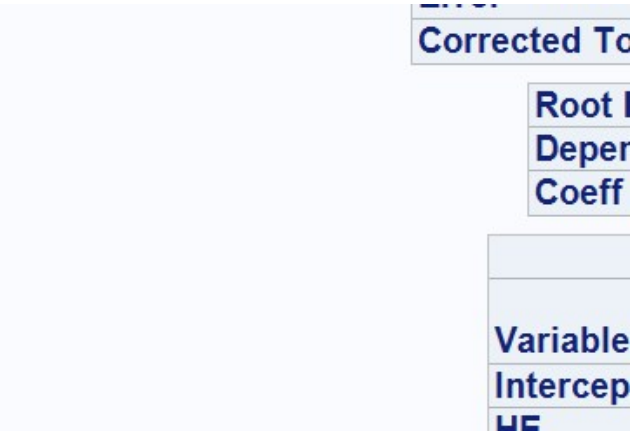
			Collinearity Diagnostics					
			Proportion					
Number	Eigenvalue	Condition Index	Intercept	HE	FD	CPIA	SAN	
1	8.68345	1.00000	0.00011079	0.00080170	0.00105	0.00022690	0.00173	0

Appendix D – Specification Test

Generated by t

Appendix E – Durbin-Watson Test

Appendix F – Regression Output



Appendix G - Countries

Afghanistan	Mali
Benin	Mozambique
Burkina Fasco	Nepal
Burundi	Niger
Central African Republic	Rwanda
Chad	Senegal
Comoros	Sierra Leone
Condo Dem. Rep.	Somalia
Eritrea	South Sudan
Ethiopia	Syrian Arab Republic
Gambia	Tajikistan
Guinea	Tanzania
Guinea-Bissau	Togo
Haiti	Uganda
Korea Dem. People's Rep.	Yemen Rep.
Liberia	Zimbabwe
Madagascar	
Malawi	