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Health: An Engine of Economic Growth

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Earlier studies have shown that human capital is one of the major determinants of economic growth. Human capital includes not only enhancement of knowledge and skill through education and training but also improvement in a person's health conditions. Health is therefore regarded as a significant determining factor for a country's prosperity. There are plenty of researches that studied the link between human capital and economic growth but very few researches have examined the role of health condition of a country on economic growth. Unlike previous studies, this study applies recent econometric techniques to explore the relationship between major health indicators and growth performance in 30 OECD countries. The Generalized Method of Moments (GMM) and panel data estimation techniques are used to obtain the empirical results. The estimated results confirm that there is a significant relationship between health indicators and economic growth in OECD countries. The robustness of the results was also tested by conducting Chow's stability and Granger's causality tests. The stability test shows that the relationship does not hold stable for entire sample period. The causality test, on the other hand, does not support much for the bidirectional relationship between economic growth and health but indicates that the causality mostly goes from health to economic prosperity.

Keywords: health expenditure, life expectancy, economic growth, GMM estimation, panel data estimation, causality test, stability test

Introduction

Economics profession witnessed proliferated literatures on economic growth particularly after Robert Solow's pioneering work in 1956. Solow's famous model of economic growth says that savings rate is an economy's driving force to determine the path of economic growth of an economy. Under the assumption of diminishing returns to capital, the economy reaches a steady state at some points where economy's growth converges to a constant rate. Only a change in exogenously determined technology and population growth departs the economy from the steady state (Barro & Sala-i-Martin, 2004).

Dissatisfied with Solow's economic growth model, particularly with the assumption of diminishing returns to capital and constant savings rate, some economists started working out with endogenous growth theory during 1980s, according to which the human capital—the skills and knowledge that make workers more productive—plays a significant role for a country's prosperity. Unlike physical capital, human capital has increasing returns, especially through learning by doing and knowledge spillovers. Since human capital embodies

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knowledge and skills, and economic development depends on advances in technological and scientific knowledge, then development ultimately depends on the accumulation of human capital (Becker, Murphy, & Tamura, 1990). This led to the violation of basic assumption of Solow's diminishing returns to capital, and in fact the evidence shows that there is a constant or increasing returns to capital when human capital is added into it. In such endogenous growth theories, the economies never reach a steady state, but instead continue to grow as a result of increasing returns to human capital.

It is, therefore, argued that growth does not slow as capital accumulates, but the rate of growth depends on the types of capital a country invest in. When talking about human capital, it is generally believed that it is the money invested on enhancing human knowledge, basically in education (Laitner, 1993). The gain in health is rarely assumed to be a part of investment in human capital, but the evidence shows that health has tremendous effect on productivity. The productivity in the twentieth century has increased by a huge amount. Output per man-hour is now nine times higher than it was in 1874 and double of its 1950 level (Blanchard & Fischer, 1996). In the same line with productivity, the twentieth century has also witnessed remarkable gains in health. An average life expectancy in developing countries was only 40 years in 1950 but increased to 63 years in 1990. Factors such as improved nutrition, better sanitation, innovations in medical technologies, and public health infrastructure have gradually increased the human life span (Bhargava, Jamison, Lau, & Murray, 2001). This close association between productivity and health justifies to believe that health is one of the major determinants of economic growth.

Growing literatures are found on the theory of human capital that supports a basic idea that health enters into the income production process. Michael Grossman pioneers in this field, and provides a conceptual ground for a relationship between health and productivity (Grossman, 1972, p. 224). As Grossman quotes:

> At a conceptual level, increases in a person's stock of knowledge or human capital are assumed to raise his productivity in the market sector of the economy, where he produces money earnings, and in the nonmarket or household sector, where he produces commodities that enter his utility function. … Although several writers have suggested that health can be viewed as one form of human capital, no one has constructed a model of the demand for health capital itself. In particular, it argues that a person's stock of knowledge affects his market and nonmarket productivity, while his stock of health determines the total amount of time he can spend producing money earnings and commodities.

Grossman's model of demand for health clearly indicates that there is a significant role of health in raising productivity. If Grossman's model is combined with traditional growth theories, a new dimension of growth theory could possibly emerge. For this purpose, a theoretical backup is needed to incorporate heath in economic growth models. It is well known that capital accumulation depends on the savings rate that is also influenced by adult health. The effect of health on savings rate makes some connection between health and economic growth because the latter depends on savings rate as claimed by Solow's model. In other words, a model can be propounded that makes link between health and economic growth through savings rate. Not only with Solow's model, health and economic growth can be linked through optimization based growth models that have been flourishing for many years in economics profession. In Solow's model, savings rate is given exogenously, and this does not allow for the consumers to behave optimally. This limitation in Solow's model led to the emergence of consumer optimization models as constructed by Frank Ramey as described by Barro and Sala-i-Martin (2004). The utility dimension of the effect of health on productivity has also been envisioned in Grossman's model. In consumer optimization models, saving rate is not constant and exogenously determined, rather it is the function of consumer preferences. The consumer preferences as depicted in the consumer utility function can better include the variables that are related to health conditions, because health condition has a lot to do with saving-consumption decisions. It looks obvious then that a model can be developed based on consumer optimization where health enters into utility function.

Without providing any theoretical structural framework, however, this paper's objective, as a starting point, is to test the effectiveness of health on economic growth for OECD countries by estimating reduced-form models. For this purpose, growth of real GDP per capita, which is considered to be a major indicator of economic growth, is regressed on health indicators of the countries, such as per capita health expenditure and/or life expectancy. The paper proceeds as follows: the following section explains brief review on related literatures, section 3 provides empirical framework, empirical results are discussed in section 4, and section 5 concludes.

Literature Review

Recognition of health condition of a country's population as one of the major driving forces of economic growth has led to many economists' attention to explore the link between health and economic growth. One of such empirical investigations was carried out by Bhargava, Jamison, Lau and Murray (2001). They estimated a model to test the effects of health indicators such as adult survival rates (ASR) on GDP growth rates at 5-year intervals in several countries. In their panel data analysis, the results showed positive effects of ASR on GDP growth rates in low-income countries. For the poorest countries, a 1% change in ASR was associated with an approximate 0.05% increase in growth rate. For most developed countries, such as USA, France and Switzerland, the estimated effect of ASR on growth rates was, however, negative, partly due to, according to authors, inappropriate choice of the functional form and explanatory variables available for the analysis. The authors also tested for causality and stability in the parameters. The findings were that the investment/GDP ratios were not significant predictors of ASR, and the null of parameter constancy was also rejected at the conventional 5% level.

Arora (2001) investigates the influence of health on the growth paths of ten industrialized countries over the course of 100 to 125 years. The results show that changes in health increased economic growth by 30 to 40 percent, and most importantly, the author also found that health changed the existing path of economic growth as well. This finding was robust for all measures of health used by the author, and remained largely unchanged when controlled for investment in physical capital.

A bidirectional interaction between economic growth and longevity was tested by Sanso and Aisa (2006). Based on the analysis in dynamic general equilibrium framework, the study revealed that the need to offset biological deterioration encouraged medical research and this also improved the conditions of health of new generations and, as a result, individual's productive capacity improved triggering economic growth. The authors showed that the rate of economic growth was exactly the same as the rate of biological deterioration. On the reverse direction, this economic growth generated a sufficient amount of resources for the financing of medical research and health expenditure, which would finally increase the life expectancy of the people.

Liu, Dow, Fu, Akin and Lance (2008) examined the extent to which individual health, as a form of human capital, contributed to household income production for the data from the China Health and Nutrition Survey (CHNS). This study provided empirical evidence regarding the income productivity of human health capital in

China. Household income was strongly influenced by the health of its members, particularly in rural areas. The authors claimed that these findings could have important implications for health and economic policy-making aimed at reducing the long-standing urban-rural economic gap and more comprehensively insuring the rural population against health and economic risk.

Empirical Framework

Data

The data for the study was obtained from OECD website. The sample ranges from 1960 to 2005. For panel estimation, the data cover all 30 OECD countries. The measurement of economic growth is measured by GDP per capita U.S. dollars. Two health measures taken for the analysis are expenditures on health expenditure per capita US dollars and life expectancy of total population at birth. The OECD website has the data on many other growth and health indicators, but data this study uses are available for whole sample period.

For GMM estimation, the instruments were selected in such a way that they were closely related to health indicators but not with error terms. To serve this purpose, the instrument list included alcohol consumption, tobacco consumption, carbon monoxide emissions, consultants per capita, public health insurance, and pharmaceutical sales. Alcohol consumption is in liter per capita for the population of 15-plus age whereas tobacco consumption is on gram per capita for the same 15-plus age population. The pollution measurement is carbon monoxide emissions in kilograms per capita. Enough data are not available for private insurance which led to the selection of public health insurance. Pharmaceutical sales is in per capita U.S. dollars.

The regressions are carried out not only with health indicators as explanatory variables but also with other important determinants of growth, such as capital and labor. The proxy for the capital is taken as per capita gross fixed capital formation whereas for the labor, it is labor force as a percentage of total population.

Model

The study uses three different regression approaches to explain the effect of health on economic growth. They are: Ordinary Least Squares (OLS), panel data approach, and the Generalized Method of Moments (GMM) estimation. The model is estimated with OLS to get the preliminary results. Due to difficulty in reporting the results for all OECD countries, the OLS is carried out just for five countries: U.S., U.K., Canada, Japan and Mexico. Panel estimation, however, covers large number of data set from all OECD countries.

Besides regression estimates, the study also conducts causality test between health and economic growth in order identify whether the relation goes two ways around or not. Stability test is conducted to examine whether or not the relationship is stable for whole sample period. The detail explanation of each model framework is explained below (except for Ordinary Least Square).

Panel Data Approach

The basic panel data model the study estimates is:

$$y_{it} = x_{it}^{'}\beta + \alpha_i + \varepsilon_{it} \tag{1}$$

where, y is dependent variable, x is vector of explanatory variables, β is vector of parameters, α is country-specific, time-invariant component (unobserved heterogeneity) and ε is idiosyncratic, time-varying error. Based on the relationship between unobserved component α and the explanatory variables, one can estimate two different models in panel data: fixed effect model and random effect model. If it is believed that there is correlation between unobserved and explanatory variables, fixed effect model is estimated. The correlation leads to biased and inconsistent estimators, but fixed effect model gives solution to this problem by eliminating unobserved component while estimating the equation. Random effect model, on the other hand, assumes that unobserved component and explanatory variables are uncorrelated. Despite the exogenous unobserved component, the model can have serial correlation in composite error term, and thus it uses generalized least square method to estimate the model to avoid this problem, which is commonly known as a random effect estimator (Wooldridge, 2006, pp. 494-495).

The study estimates both fixed effect and random effect models. The reason for using fixed effect model is that the health condition of a country is likely to be affected by country-specific factors, such as country's population, availability of resources and so on others (these factors do not change much over time and all included in α). Such effects are controlled in estimating the model with fixed effects. The reason behind using random effect is that even though it is assumed that country-specific factors may not have any effect on heath conditions, the composite error terms (which includes α and other time-variant disturbances) are most likely to be serially correlated.

GMM Estimation

The generalized method of moments (GMM) estimation technique is widely used in recent days as one of the most efficient econometric techniques to estimate a regression model. It has been shown that the regression models developed prior to GMM (such as OLS, maximum likelihood, method of moments) are the special cases of GMM (Hall, 2005). The basic foundation of GMM is moment conditions that come from economic theory. As mentioned earlier, the theoretical formulation of a growth model taking account of health is out of this study's scope, the moment conditions are derived from the assumption that the error terms are uncorrelated with the instruments as listed before. The model formulation proceeds as follows.

The linear regression model of *y* on *x* is:

$$y_t = x_t'\theta_0 + u_t \tag{2}$$

where, y_t is the dependent variable, x_t is the $p \times 1$ vector of explanatory variables, θ is the $p \times 1$ vector of parameters, and *u* is the error term.

The moment condition comes from the theoretical relationship between error terms and the $q \times 1$ vector of instruments z_t as:

$$E[z_t u_t(\theta_0)] = 0 \tag{3}$$

The identification condition is:

$$rank\ \{E[z_t x_t']\} = p \tag{4}$$

The generalized method of moments estimator minimizes:

$$J(\theta) = T^{-1}\sum_{t=1}^{T}(y_t - x_t'\theta)'W_T(y_t - x_t'\theta) \tag{5}$$

where W_T is the weighting matrix.

The minimization gives GMM estimator in matrix notation as:

$$\hat{\theta}_T = \{(T^{-1}X'Z)W_T(T^{-1}Z'X)\}^{-1}(T^{-1}X'Z)(T^{-1}Z'y) \tag{6}$$

Here, *T* is the sample period, matrix *X* contains the data on explanatory variables (health expenditure per capita, life expectancy, gross fixed capital formation, and labor force), matrix Z contains the data on instruments as listed above, and the vector y contains the data on dependent variable (real GDP per capita).

Stability Test

In regression analysis, the question often arises as to whether or not the parameters are stable across various subsample periods. In order to address this question, this study applies the methodology proposed by Chow (1960). The idea behind Chow test is simple that it fits the equation separately for each sub-sample and tests whether there are significant differences in the estimated parameters by applying standard F-test.

Causality Test

Correlation does not necessarily mean causation. In estimating regression equations, the causation goes from independent variables to dependent variables (unless the lagged dependent variable is included in the model), but the model does not provide any information about the relationship that may go other way around, that is, dependent variables to independent variables. Cleve Granger first proposed a model to test the bidirectional relationship between variables, which says whether x causes y is to see how much of the current y can be explained by past values of y and then to see whether adding lagged values of x can improve the explanation (Granger, 1969). y is said to be Granger-caused by x if x helps in the prediction of y, or equivalently if the coefficients on the lagged x's are statistically significant.

Empirical Results

OLS Estimation

In OLS estimation, per capita GDP (GDP) is regressed on per capita health expenditure (*HE*), life expectancy (*LE*), gross fixed capital formation (*K*), and labor force (*L*). Two models are estimated for each country taking health expenditure and life expectancy separately as independent variables. As explained before, the models also include two other determinants of economic growth, labor and capital.

The estimated results show that per capita health expenditure positively affects per capita GDP in all five countries (see Table 1). The elasticity coefficient of 0.52 of USA, for example, indicates that one percent increase in per capita health expenditure produces 0.52 percent increase in US real GDP. The coefficients for all countries are almost in same magnitude, and all are statistically significant. When the model is estimated with life expectancy, significant positive coefficients were again obtained for all countries but the U.S., indicating that people's longer life would contribute for higher economic growth. The real odd negative coefficient for the U.S. is attributed to methodological problem. The close observation of data shows that per capita GDP and life expectancy are moving in the same direction indicating that there is a clear positive relationship between U.S. per capita GDP and U.S. life expectancy. The multicollinearity problem between labor force and life expectancy is one of the potential explanations because when labor is omitted from the model, the coefficient on life expectancy turns out to be positive.

Panel Data Estimation

The OLS estimation seems pretty good at first sight, but the obvious problem with the OLS in estimating time series data is the possibility of spurious results. Because of the non-stationary nature of the data, the results do not deserve to be entirely believed as they seem in terms of high adjusted R-squares and significant coefficients as shown by *p*-values of *t*-statistics and *F*-statistics. Therefore, to make the results more trustworthy, the panel estimation has been applied that covers entire range of data and gives solution for biased and inconsistent results that OLS might have produced.

Table 1

OLS Estimation: Dependent Variable: log(GDP)

Country	Explained by				Test statistics	
	log(HE)	log(LE)	log(K)	Log(L)	Adj. R^2	*p*-value for *F*-stat
USA	0.52 (0.00)	-	0.36 (0.00)	-0.26 (0.54)	0.999	0.00
	-	-2.64 (0.04)	0.15 (0.04)	3.65 (0.00)	0.998	0.00
UK	0.56 (0.00)	-	0.39 (0.00)	-0.53 (0.26)	0.999	0.00
	-	5.73 (0.00)	1.04 (0.00)	-3.45 (0.00)	0.99	0.00
Canada	0.43 (0.00)	-	0.38 (0.00)	0.36 (0.01)	0.999	0.00
	-	2.31 (0.50)	0.59 (0.00)	0.95 (0.20)	0.985	0.00
Japan	0.45 (0.00)	-	0.48 (0.00)	0.61 (0.00)	0.999	0.00
	-	7.28 (0.00)	0.82 (0.00)	-0.21 (0.52)	0.999	0.00
MEX	0.48 (0.00)		0.35 (0.00)	-0.05 (0.31)	0.996	0.00
		4.44 (0.00)	0.73 (0.00)	-0.28 (0.10)	0.98	0.00

Note. Figures in parentheses are *p*-values for *t*-statistics.

The results are decent with this estimation technique. All coefficients for health expenditure and life expectancy are positive and statistically significant (see Table 2). The negative coefficient with life expectancy for U.S. in OLS estimation has now been corrected. One possible explanation for this is that the country-specific characteristics of the U.S. could be highly correlated with health conditions, and therefore fixed effect estimator eliminated this problem and produced positive coefficient. For the random effect estimator, it can be said that the error terms from OLS were serially correlated (this is what happens in time-series OLS), and they were corrected with random effects estimator, producing positive coefficient for the U.S..

GMM Estimation

Two separate models were estimated for each of five countries treating health expenditure and life expectancy as endogenous variables. The results almost look similar to OLS estimation, but there is one important distinction. The coefficients from GMM are smaller in almost all models than they are in OLS estimation (see Table 3). The OLS model produced upward biased results, but by treating health expenditure and life expectancy with instruments, the coefficients have now reduced, and the coefficients are believed to be consistent as suggested by GMM.

The coefficient for the U.S. still remained negative, but with lower magnitude. When labor force is omitted from the model as it did with OLS, the coefficient turns positive.

Table 2

Panel Data Estimation: Dependent Variable: log(GDP)

Specification	Explained by				Test statistics	
	log(HE)	log(LE)	log(K)	Log(L)	Adj. R^2	p-value for F-stat
Common intercept	0.45 (0.00)	-	0.41 (0.00)	-0.03 (0.00)	0.90	0.00
	-	4.01 (0.00)	0.78 (0.00)	-0.02 (0.02)	0.88	0.00
Fixed effects	0.47 (0.00)	-	0.38 (0.00)	-0.22 (0.00)	0.99	0.00
	-	4.94 (0.00)	0.67 (0.00)	-0.31 (0.00)	0.99	0.00
Random effects	0.45 (0.00)	-	0.38 (0.00)	-0.08 (0.00)	0.99	-
	-	4.47 (0.00)	0.66 (0.00)	-0.09 (0.01)	0.99	-

Note. Figures in parentheses are p-values for t-statistics.

Table 3

GMM Estimation: Dependent Variable: log(GDP)*

Country	Explained by				Test statistics	
	log(HE)	log(LE)	log(K)	Log(L)	Adj. R^2	J-statistic
USA	0.39 (0.00)	-	0.32 (0.00)	0.36 (0.00)	0.997	0.23
	-	-0.65 (0.04)	0.52 (0.00)	0.73 (0.00)	0.97	0.17
UK	0.55 (0.00)	-	0.25 (0.00)	0.38 (0.00)	0.99	0.21
	-	5.95 (0.00)	0.63 (0.00)	-2.05 (0.00)	0.97	0.36
Canada	0.14 (0.04)	-	0.33 (0.00)	0.64 (0.01)	0.86	0.15
	-	0.39 (0.01)	0.30 (0.00)	0.61 (0.20)	0.84	0.19
Japan	0.43 (0.00)	-	0.62 (0.00)	0.12 (0.00)	0.999	0.07
	-	6.00 (0.04)	1.07 (0.00)	-2.32 (0.05)	0.98	0.19
MEX	-0.59 (0.08)	-	1.29 (0.00)	0.28 (0.00)	0.80	0.04
	-	0.61 (0.01)	0.75 (0.00)	0.07 (0.47)	0.93	0.06

Notes. * Figures in parentheses are p-values for t-statistics. Instruments: Alcohol consumption, emissions of carbon monoxide, public health insurance, consultants available, tobacco consumption, and pharmaceutical sales. Some instruments have been dropped for some countries due to unavailability of data or no obvious change in the data.

Stability Test

The model was estimated taking 1990 as a break point. This is not the year when a significant change in policy regime with regard to health was witnessed in those countries, but the goal of this paper is merely to test whether the relationship holds for whole sample period or not. The results show that the coefficients are not stable for most of the countries (see Table 4).

This is also true for the model with life expectancy as well. The nulls of stable coefficients have been rejected for all countries. The U.S. and Japan have unstable coefficients in both models.

Table 4

Stability Test (p-values for F-statistic)

Country	Model 1	Model 2
USA	0.00	0.00
UK	0.12	0.00
Canada	0.17	0.00
Japan	0.02	0.01
Mexico*	0.18	0.01

Notes. Model 1: log(GDP) = constant + log(HE) + log(K) + log(L); Model 2: log(GDP) = constant + log(LE) + log(K) + log(L); Break point: 1990.

Causality Test

The bidirectional relationship between health and GDP is not strongly evidenced as shown by causality test results in Table 5. When taking GDP and health expenditure as two variables believed to affect both ways around, very few nulls of no Granger cause have been rejected. For U.K., the relationship exists in both ways. For the U.S., while the test statistic fails to reject the null of health expenditure does not Granger cause GDP, GDP does Granger cause health expenditure. The evidence of the causation from GDP to health expenditure is in line with the result of Goodman (2000) for the U.S., U.K., but not for Canada, Japan and Mexico. With life expectancy, more nulls have been rejected.

Table 5

Causality Test (p-values for F-Statistics)*

Country	Health expenditure (HE)		Life expectancy (LE)	
	HE does not Granger Cause GDP	GDP does not Granger Cause HE	LE does not Granger Cause GDP	GDP does not Granger Cause LE
USA	0.23	0.07	0.02	0.27
UK	0.03	0.03	0.02	0.42
Canada	0.93	0.93	0.09	0.23
Japan	0.35	0.84	0.87	0.25
Mexico*	0.66	0.63	0.00	0.07

Note. * The models include four lags.

Conclusion

The human capital has long been recognized as one of the major determinants of economic growth. Along with the knowledge acquired through education and training, human capital also comprises the improvement in a person's health condition. With the pioneer work of Grossman (1972), a foundation was provided for a conceptual ground for a possible existence of the relationship between health and income productivity. Since then, growing number of literatures are emerging and they provide encouraging indications that the improving health indicators of a country have a tremendous role to affect the country's economic growth. This study's primary objective is to offer a new empirical support in this emerging field. The study uses three different approaches to test the effect of health on growth: ordinary least square (OLS), panel data approach and generalized method of moments (GMM) estimation technique. While the results in three different models slightly differ, all models have confirmed the positive relationship between health and economic growth. The stability test shows that the relationship is not stable throughout the whole sample period for most of the countries, but this does not mean that the positive relationship does not hold. The causality test does not support much for the hypothesis that the relationship between economic growth and health goes both ways.

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