The Macroeconomic Impact of Improving Health: Investigating the Causal Direction.

by

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Abstract

Causality between income and health is not yet fully understood nor is there a generally accepted unidirectional gradient even though a strong correlation has been observed between health and income as early as the mid-19th century. The economics literature abounds in research that has examined the determinates of health inequalities using economic class as a causal variable to predict health status without considering the possibility that health itself may determine economic or social position. This paper addresses the macroeconomic effect that health has upon the United States economy since the turn of the century. Economic studies are still ambiguous on the causal relationship between the effects of health and income with support for each relationship seemingly available. This paper uses aggregate income (GNP) in 1987 constant prices and four well-known indicators of health (Life Expectancy, Infant Mortality, Death Rates, and Investment in Medical Research) as data variables to measure the direction of causality. A Granger Causality framework using parametric F-tests strongly indicates that causality flows only from improving health to rising incomes (or from poorer health and declining incomes). Decreasing Death Rates and Infant Mortality, extending Life Expectancy and increasing Investment in Medical Research have played an important and significant role in increasing GNP.

Key words - inequalities in health, socioeconomic status, health economics

INTRODUCTION

Economic growth has been at least partially if not entirely driven by improving health. Robert Fogel (1997) has asserted that as much as 30% of Britain's per capita economc growth rate between 1780 and 1979 was due to improved nutrition contributing to increased longevity. This resulted in greater social and human capital investment followed by economic growth. David Bloom and Jeffrey Williamson (1998) and an Asian Development Bank report make the claim that the reduction in mortality leading to the demographic transition resulted in a greater proportion of working age people and a low dependency ratio. As much as one third to one half of the Asian economic "miracle" between 1965 and 1990 was a result of the change in demographics (Asian Development Bank, 1997; Bloom and Williamson, 1998).

Needless to say, the relationship between health and income is not so simple. Strong correlations have been found between income levels and health. The relationship between income levels and health levels forms the "gradient" so often observed when economics and public health converge. This relationship is well established in the literature where socioeconomic status has shown a strong and consistent negative correlation with morbidity and mortality (Antonovsky, 1967; Bunker, Gomby and Kehrer, 1989; Feinstein, 1993; Gwatkin, 2000; Marmot, Kogevinas and Elston, 1987; Sen, 1999; Greek, 2001). Specific factors that mediate the relationship are unclear and generally untested (Greek, 2000, 2001). However, David Bloom and David Canning (2000) do suggest several economic mechanisms whereby health influences wealth or income.

At the same time, the association between income distribution or inequality and health also appears to have a strong and consistent negative correlation where the greater the inequality, the poorer the health (Kitagawa and Hauser, 1973; Barker, 1990; Preston and Taubman, 1994; Rogers, Hummer and Nam, 2000; Williams and Collins, 1995; Kaplan, et al., 1996; Fiscella and Franks, 1997; Kawachi and Kennedy, 1997; Kawachi and Kennedy, 1997a;

Wilkinson, 1992; van Doorslaer, et al., 1997; Gakidou, Murray and Frenk, 2000; Acheson, 1998; Feachem, 2000; Gwatkin, 2000). Similar to the relationship between health levels and SES status, research is sparse that link causes of poor health with income inequality and to quantifying interventions to reduce health inequalities (Wagstaff, 2000). Mayston (2000)posits several economic mechanisms that could account for the health disparities. These mechanisms consist of spatial and economic correlates, relative price changes as income increases, and hysteresis from past economic shocks.

This second income construct is a "relative poverty" measure and is both time and location specific (Gwatkin, 2000). This measure is not in terms of money but rather in proportions or ratios of income. Generally, this measure is often the Gini coefficient which is an index accounting for each quintile of a population. Numerous other measures have been used such as the ratio of the highest income group divided by the income of the lowest group but all are shown to be highly correlation with each other and with health (Kawachi and Kennedy, 1997a).

Neither the income measure nor the income inequality metric are able to compare rich and poor across countries. However, a third metric, income position, can be used to compare rich and poor across countries holding income and income distribution constant. This metric is ones position in a countries income quintiles. In an operational context, this metric is merely a dummy variable indicating which income quintile a group is positioned. Hence, a group with an annual income of $10,000 may be among the poor in England (in the lowest income quintile) but the rich in Bangladesh (in the highest income quintile). One (group or individual) in the lowest income quintile is the poorest while one in the highest income quintile is the richest. The middle income quintile can be thought of as the middle class. Teh reamining two quintiles can be thought of as the upper middle class or lower middle class. This metric is able to investigate relative income status between countries and is rare in the literature (Brinkley, 2001).

Whichever metric one uses to investigate the nebulous relationship between health and income determines which public policy to advocate. Kaplan et al. (1997) assert that economic and social policies designed to reduce uneven income distributions would have important positive health effects. Kawachi and Kennedy (1997) argue that since many public policies encourage increases in income inequality, and a strong correlation exists between income inequality and poor health, then public policies reducing inequality will go far in improving population health. D. Gwatkin (2000) lays out a course for health care professionals to influence public health policy through advocating social and economic equality. Many practitioners of public health claim that policies that address health inequalities are of high priority in defining interventions to reduce ill health (Acheson, 1998; Beaglehole and Bonita, 1998; Kaplan and Lynch,1997; Kawachi and Kennedy, 1999).

However, the causal relationship is of utmost importance in advocating effective public policy interventions. The relationship may be bi-directional as noted by Richard Feachem (2000) who states "Poor health is a common consequence of poverty and poverty can be a consequence of poor health." He goes on to note that new thinking of health and income ignores the causal relationships between health and income by claiming that "Poor health is a component of poverty rather than a cause or consequence." However, if poor health is neither a cause of nor a result of poverty, economic redistribution can be seen to be less important than tried and true public health interventions such as vaccinations, sanitation, or clean water supplies.

A recent study by Brinkley (2001) indicates the relative effects that the three income metrics have upon the infant mortality rate and the under 5 mortality rate in 22 developing countries. The absolute amount of income is most important and always highly statistically significant so that a one unit change in income (income in natural logs) results in a decrease of 29 to 35 infant deaths per thousand births and 53 to 70 under 5 deaths per thousand births.

At the same time, income inequality measured as the Gini coefficient was not statistically significant and is mostly negative which is a contra result to most of the studies referenced above. However, this result could have occurred as a result of the data structure since the obsrvations was by income/wealth quintile.

Income position was both highly significant and positively related to IMR and U5R after holding income and income distribution constant. Essentially, the poor in a wealthy county have lower mortality than the rich in a poor country. A gradient was formed with the lowest income quintile having the lowest IMR by about 7 and U5R about 20 deaths for each step up the income quintile ladder. Hence, the difference in IMR between the rich and poor was an IMR of 28 deaths higher. This result is similar to Waldmann (1992) who found that after controlling for the income of the poorest twenty percent of the population, the greater the income share of the top five percent was associated with higher infant mortality.

Of even greater importance than the correlations between health and income is the causal direction. Researchers from different social sciences have reached different conclusions on the causal relationship between health gradients and economic classes. Evans and Stoddard (1990), for example, argue that cuts in health care spending should be redirected towards wealth producing investments since higher incomes begat better health. Their view tends to correspond with the prevailing view among economists when addressing the macroeconomic implications of health improvements, i.e. health improvements have come about as a result of higher incomes. Poland *et al*. (1998), on the other hand, dispute the "population health" notions of Evans and Stoddard (1990) that spending on health care should be discontinued or reduced and the moneys saved be invested into increased prosperity as a more successful goal. As Poland *et al*. pointed out, health care spending and health status are not the same thing. In a historical framework, as the economies of the developed nations grew, health improved. The general viewpoint seems to be that the industrial revolution preceded and caused improvements in the health status of the population.

In a modern day macroeconomic setting, this same belief is held where the citizens of rich countries are healthier as measured by longer lives, lower rates of infant mortality and death rates as a result of their accumulated wealth. Kibirige (1997) explores the relationship between poverty and health in modern day Africa and concludes that a vicious cycle exists where poverty causes poor health with in turn leads to more poverty. Countries whose average per capita income are relatively low suffer ill health leaving their citizens with short and relatively unproductive lives. The past macroeconomic policy emphasis in developing nations has concentrated on increasing income and awaiting the health revolution. This trickle down approach to improving health care in the third world appears to have failed with development specialists now recognizing the need for a different approach (Slottje, 1991). This view is now echoed by public health professionals who accept the proposition that reducing poverty or the mal-distribution of income or wealth will lead to a bettering of health status (Black, 1980; Evans, et al., 1994; Navarro, 1997).

Methods used in assessing causal directions between economic factors and health levels are many and varied depending mostly upon the researchers educational background. Public health epidemiologists rely on the Henle-Koch postulates and tend to favor prospective cohort studies while economists tend to favor either a Granger-Causality framework or the more recently developed Control Systems framework (Hoover, 1990, 1991, 1993; Hoover and Sheffrin, 1992).

This paper uses a Granger-Causality framework to determine the causal direction between aggregate income changes and changes in health levels. This particular methodology, well studied and robust in small samples (Geweke and Meese, 1981), has been extensively applied to test causal directions between GNP as an aggregate income measure and interest rates, money supply measures, and government expenditures. This methodology has been used to justify the intervention by the Federal Reserve System (in terms of interest rate changes, bond sales (Open Market Operations), or changes in the reserve requirement ratio) or by the Federal government in terms of increased spending to spark economic growth. (Andersen and Jordan, 1968; Gordon, 1971; Sims, 1972; Goldfeld and Blinder, 1972; Elliott, 1975; Sargent, 1976; Carlson and Hein, 1980; Hsaio, 1981; Hafer, 1982; McMillin and Fackler, 1984; Singh and Sahni, 1984; Batten and Thornton, 1983a, 1983b, 1983c; Thornton and Batten, 1985; Holmes and Hutton, 1990).

Aggregate income in the United States has increased and the general level of health has improved over the past century. A clear statistical connection exists between GNP in constant dollars and health levels as measured by Life Expectancy, Infant Mortality, Death Rate, and Investment in Medical Research. Generally, the relationships are statistically significant and reflect the expected relationship. In TABLE 1, a simple bivariate OLS regression between GNP in 1987 dollars as the dependent variable and the independent health variable (there are four), interest rate, or the money supply (M2) shows a significant statistical relationship.

TABLE 1
BIVARIATE REGRESSION RESULTS FOR FACTORS INFLUENCING GNP

VARIABLE	CONSTANT	COEFFICIENT	T-STAT.	R^2	OBSERV.
LNLIFE	-4.07	3.17	19.21	.80	93
LNINFANT	11.42	-0.66	-26.87	.90	78
LNDEATH	14.34	-2.22	-16.62	.75	92
LNRESEARCH	8.88	0.22	13.19	.80	45
LNINTRATE	8.79	0.14	2.14	.04	102
LNM2	6.32	0.43	59.87	.97	125

All variables are in natural logs.
Notes: All the constant terms in each regression are significant at the 99% level. GNP is measured in 1987 prices.

The interpretations of the coefficients of the independent variables are straight forward since they are elasticities. A 10% increase in average life expectancy will increase GNP by 31.7%. An increase of 10% in the infant mortality rate will decrease GNP by 6.6%. A 10% increase in the M2 money supply would increase income by 4.3%. The remaining coefficients have similar interpretations. What is particularly noticeable from TABLE 1 are the greater impact changes in the measures of health have on GNP than either the interest rate or the money supply. What the relationships in TABLE 1 fail to indicate is the causal direction. The very real possibility exists that changing GNP has a great and immediate influence on the changes in the health measures. Testing the direction of causality can be accomplished by using criteria initially suggested by Granger (1969).

GRANGER CAUSALITY CRITERIA

In order to test for parametric causality between two events, Granger indicated two criteria that needed to be met. First, a mechanism must exist that is intuitive or reasonable explaining why one factor would influence the other. This was specified by Suppes (1970) as a "relevant theoretical framework" and reinforced by Zellner (1979), Holland (1986), Basmann (1988), and, of course, Granger (1980, 1988). The second criterion is that one event must precede the other in time.

The first possible relationship between aggregate income and health is that each is independent. Second, causality may be a two-way street. Third, causality may flow from income to health. And, finally, improvements in health may lead to greater income.

MECHANISMS RELATING HEALTH AND INCOME

Since causality is not intuitively clear between health and income, economists have offered different mechanisms which link income and health. In the first case each variable is independent of the other so no mechanism actually exists that link income and health (Wagstaff, 1986; Easterlin, 1995).

⇑ HEALTH <=/=> ⇑ INCOME

In the second case, however, much of the public health literature asserts that income and health are intertwined with each having a dramatic influence upon the other (R. Steckel, 1995; Feachem, 2000). The general relationship can be illustrated as follows:

⇑ HEALTH <===> ⇑ INCOME

The double arrow indicates that each factor has influence upon the other. However, the relative sizes of the direction of causality may not be equal where income may have greater impact upon a person's health status than the reverse. The relationship implies a positive cyclical relationship where better health results in higher income and higher income leads to better health.

The third case, where improving health flows from higher income seems to be the prevalent position among health economists. Economists have traditionally given health improvements little consideration in explaining productivity growth (Mechanic, 1978; Grossman, 1972a; Haveman, *et al*., 1994). The mechanism which relates health to income can be illustrated as follows:

⇑ INCOME => ⇑ DIET and/or ⇑ MEDICAL INTERVENTION => ⇑ HEALTH

The mechanism in this relationship implies that high income translates into better diets which imply greater nutrition and hence, a stronger body and sounder mind which is, by definition, better health. Engle's Law (as income increases more will be spent on food albeit at a slower rate than the overall rate of increase) tends to support this contention. In addition, a higher income also implies greater medical interventions leading to a higher level of health.

In the last case, the mechanism which explains a one way relationship going from health to income is generally asserted to be through the effects of changes in job characteristics in the short run. These are changes in time worked and productivity. However, longer run effects have also been suggested. To wit:

⇑ CONSUMPTION & PRODUCTION PATTERNS

⇑ HEALTH => ⇑ WORKING HOURS, ⇑ PRODUCTIVITY => ⇑ INCOME

⇑ OPTIMISM

Simon Kuznets (1965) suggested a long term connection between improved health and increasing income to the effect that better health creates optimism in the future which is necessary for long term economic planning which increase savings. Increased savings imply increased investment and higher economic growth. An individual is more likely to invest in themselves when the payoff is greater. Therefore, when average lifespan increases, the return on education becomes greater and rational individuals can be expected to increase their education level. If an average life expectancy is 50, then little can be expected to be saved towards retirement whereas if life expectancy is 75, savings rates would be expected to be greater to smooth consumption before and after retirement.

In addition, changes in consumption and production demographics brought about by severe disease epidemics can substantially influence purchasing patterns, savings rates, and age-related productivity. Fuchs (1972) suggested that healthier people would have greater consumption and be more productive.

DATA DESCRIPTION

Data variables used in this analysis are Gross National Product (GNP) in 1987 dollars, Life Expectancy, Infant Mortality Rates, Crude Death Rates, and Investment in Medical Research also in 1987 dollars. By using constant dollars, inflationary effects are eliminated which would have little bearing on health levels.

The Gross National Product data from 1959 to 1993 were taken from the Economic Report to the President. Historical Statistics of the United States provided the remainder. The values were converted into 1987 per capita constant dollars and extend from 1900 to 1992. Generally, GNP has been increasing with major deviations corresponding to the Great Depression and WWII.

For each aggregate health measure, data were taken from Kurian's Datapedia of the United States 1770-2000: America Year by Year. The life expectancies of Americans have increased from approximately 35.5 years in 1789 to 75.7 years in 1992. Major fluctuations in life expectancy occurred before the discovery and subsequent use of the so-called miracle drugs in the early 1940's. After WWII, there has been a steady increase in how long people can expect to live of about 0.15 years per annum.

Infant mortality has undergone a steady decline over the past century. In the early 1910s, one out of ten infants failed to reach adulthood. Currently, less than one in one hundred dies. The major deviations from the trend occurred prior to the mid-1930s.

The crude death rate in the United States has consistently fallen since the beginning of this century but with substantially greater deviations from trend than any other health measure. In 1900, approximately 17 people per 1,000 died each year; today, less than nine die per year.

The last health measure used in this analysis is Investment in Medical Research. While the trend is generally upward, notable downturns occurred during the late 1960s and early 1980s.

GRANGER CAUSALITY MODEL

The Granger causality model estimates four OLS equations, one pair restricted and the other pair unrestricted, and compares the F-Statistic obtained with a predetermined critical value to assess the strength of the causal relationship. Granger causality has recently been applied to test the relationship between macroeconomic fluctuations and employment in the health sector with the determination that health sector employment lags behind GNP fluctuations (Kendix and Getzen, 1994), but has not yet been used to test the causal direction between aggregate health indicators and aggregate income. The linear equations to be estimated are:

$$g(GNP)_t = \alpha_0 + \Sigma_i^{m1}\beta_i g(GNP)_{t-i} + \Sigma_i^{m2}\gamma_i g(HEALTH)_{t-i} + \kappa_0 TREND + \epsilon_{t1} \quad (1)$$

$$g(GNP)_t = \alpha_0 + \Sigma_i^{m1}\beta_i g(GNP)_{t-I} + \kappa_0 TREND + \epsilon_{t1} \quad (2)$$

$$g(HEALTH)_t = \eta_0 + \Sigma_i^{m1}\delta_i g(HEALTH)_{t-i} + \Sigma_i^{m2}\lambda_i g(GNP)_{t-I} + \kappa_0 TREND + \epsilon_{t3} \quad (3)$$

$$g(HEALTH)_t = \eta_0 + \Sigma_i^{m1}\delta_i g(HEALTH)_{t-I} + \kappa_0 TREND + \epsilon_{t4} \quad (4)$$

ϵ_{t1}, ϵ_{t2}, ϵ_{t3},and ϵ_{t4} are assumed to be i.i.d. The g(*) indicates first differencing of the variables. The TREND is merely the year (e.g. 1900 to 1993). Lags indicate the number of prior first differences included in each equation (e.g. a lag of 3 would indicate that the three immediately prior years were included). The number of lags in each equation may differ. Hence, m1 in equation 1 (GNP lags) may have 2 lags and m1 in equation 3 (HEALTH lags) may have 20. Similarly, for m2. Each of the equations can be estimated by least squares as unrestricted and restricted (i.e., H_o:γ_1=γ_2=...=γ_i= 0 in equation 2 and H_o: λ_1=λ_2=...=λ_i= 0 in equation 4), thereby providing the necessary criteria for a parametric F-test. The direction of causality can then be tested by using F-Tests for both constrained and unconstrained regressions to determine the level of significance. The results of the F-tests support which of the four possible causal relationships exist between income and health.

The four possible outcomes of the parametric F-Test correspond to the four possible causal relationships between changing income and changing health levels. If the F-Statistics are not significant for each pair of equations (1 and 2; 3 and 4), then each variable is independent. If both F-Statistics are significant, then causality is circular (Conover and Iman, 1982; Olejnik and Algin, 1985). If the F-Statistic is significant for equations 1 and 2 while it is not in equations 3 and 4, then causality runs from HEALTH TO GNP. Finally, if the F-statistic is significant for equation 3 and 4 but not for equation 1 and 2, then one can conclude that changes in GNP are caused by changes in HEALTH. The parametric Granger F-Statistic test is relatively easy to use with good small sample properties and with little loss from lag formulation (Guilkey and Salemi, 1982).

This method does not ensure a true specification. The parametric F-test used in this analysis is actually a test of prima facie causality (Granger, 1980; Holmes and Hutton, 1990) where a third factor may be influencing each of the two variables.

All of the variables are first differences with each estimated equation having a time trend which ensures that the data conform to the stationary stochastic time series requirements which are necessary for testing in a Granger Causality framework (Nelson and Kang, 1984). Lagged dependent variables in the equations eliminate any serial correlation from the residuals (Guilkey and Salemi, 1982).[1] However, the actual results of the parametric F-test are influenced by the length of the lags used in each formulation (Fey and Jain, 1982; Guilkey and Salemi, 1982; Thornton and Batten, 1985).

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[1] The autocorrelations disappear with the first differencing and the time trend variable is not significant in any equation.

Lag selection followed a process first suggested by Hsaio (1981) which necessitated determining the first optimal lag length, then holding that length constant and determining the second lag length. Hence, $m1=m1^*$ when m2 was selected. For each variable the selection of the optimal number of lags was based on allowing m1=1,...,25, then m2=1,...,25. In the first equation 1, for example, the optimal lag for GNP was $m1^*=1$ after testing all GNP lags from 1 to 25. Then holding $m1^*=1$, m2, the lag for Life Expectancy, was selected at $m2^*=4$ after testing lags from 1 to 25.

Arbitrarily selected lag lengths can generate differing outcomes of the Granger test so the selection filter used was suggested by Thiel (1961) where the residual variance (RVC) is minimized

The Theil criteria selected $m1^*=1$ for GNP. For Life Expectancy, $m2^*=4$ after setting $m1^*=1$. In equation 2, the criteria choose $m1^*=17$ and $m2^*=1$. The results are given in TABLE 2 with causality going from Life Expectancy to per capita GNP strongly indicted. Parallel procedures were used to select for the optimal lag lengths for the other health indicators. For every other health indicator, Infant Mortality, Death Rate, and Investment in Medical Research, the conclusion strongly indicates causality going only from HEALTH to INCOME. In TABLE 2, the first column indicates the bivariate model and direction with the dependent variable listed first and the independent variable listed after the slash. The second column shows the number of lags for each model. The third column shows the F-Statistic for each model with the fourth column giving the probability of the F-Statistic occurring randomly. The final column shows the direction of causality, if any.

TABLE 2

GRANGER CAUSALITY TESTING FOR AGGREGATE INCOME AND HEALTH MEASURES

MODEL	LAGS	F-STAT.[1]	p<PROB.[1]	CAUSAL DIRECTION
GNP/LE	1/4	4.480	0.00256	LE --> GNP
LE/GNP	17/1	0.225	0.6369	GNP -/-> LE
GNP/IF	1/1	16.722	0.0001	IF --> GNP
IF/GNP	25/1	0.750	0.3954	GNP -/-> IF
GNP/DR	1/2	19.234	0.0000	DR --> GNP
DR/GNP	18/1	0.169	0.6827	GNP -/-> DR
GNP/MR	1/1	90.034	0.0000	MR --> GNP
MR/GNP	1/1	0.2365	0.6296	GNP -/-> MR

Notes: The F-Statistics and the p<Prob. values were computed using TSP Version 4.2.

The F-test results from the Granger causality framework strongly indicate that the direction of influence runs only from improving health to rising income. The results are even more robust when considering that four different health measures were used and length of the data series varied with each health series. Life Expectancy and Death Rate each has a series length beginning at 1900 and lasting until 1991. Infant Mortality data begin in 1915 and end in 1991. Finally, data for Medical Research begin in 1948 and end in 1991. Causality between HEALTH and GNP is clearly a historical phenomenon and not a recent phenomenon.

CONCLUSION

The impact of health on income is important in assessing many of the current government policies of income redistribution and economic growth. For example, the current belief that higher income leads to better health implies that worker training programs, unemployment insurance, and income redistribution policies improve an individual's health status by raising their income. Thus, government policies geared to increasing income and wealth would have the added secondary benefit of improving the health of Americans. However, since the causal direction is from health to income, government expenditures for health care will be more effective in increasing productivity, thereby increasing income and wealth. It follows that government policies aimed directly at improving health should be emphasized and funded. An added benefit is that increasing productivity and incomes by improving health care lead in turn to an expansion of tax revenue.

The results suggest several avenues to explore. Future research will focus upon the relationship between differing health levels by race and gender and their effects on income. Convergence and divergence of incomes between nations could be caused by the changes in health levels implying that investments in health programs would be of greater benefit than other types of capital improvements. In addition, linking major past economic events with severe disease episodes can resolve several past economic puzzles and has applications to business cycle theory. Finally, the implications for investing in public health rather than in economic aid are considerable.

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