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ECONOMICS 699

Do Income and Income Inequality Explain the Variation in Life Expectancy Across Countries?

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Introduction

There is a striking relationship between socioeconomic status, health and longevity. Residents of countries with higher incomes and more wealth tend to be healthier and live longer. While this relationship is well documented and quite significant, its causes are still a topic of debate. Do healthier people deliberately save more (and possibly work more) because they expect to live longer and need more savings to support their longer lives? Alternatively, does having more income and wealth because of better access to healthcare or lower stress cause people to be healthier? Or does poor health, due to higher medical expenses, decreased work and lower earnings cause people to have lower income and wealth? Are there other factors such as environment, personality, education or genetics that jointly influence lifestyle decisions affecting both health and economic status?

Significance

The question of interest as pertains to this paper is; does income protect health, and does income inequality endanger it?

Poor aggregate health may pose an obstacle to a country's economic development. Deaton (1999) argues that health promotes well-being, just as income promotes well-being. Unhealthy societies impede the process of economic development. Scully (2000) contends that a primary function of the government is to improve the quality of its citizens' lives and increasing the length of one's life would seem to be paramount.

Theory

One measure of a country's standard of living is per capita Gross Domestic Product (GDP), and studies consistently show that it is related to life expectancy. At birth, life expectancy is defined as "the number of years a newborn infant would live if prevailing patterns of mortality were to stay the same throughout its life" (World Bank 2001: 117). Population health, whether measured positively by life expectancy or negatively by mortality, improves with average income, but at a decreasing rate. This is sometimes referred to as the absolute income hypothesis, which emphasizes that income matters for health, not income relative to others' income or income inequality.

The more recent relative income hypothesis is that the health of individuals in a society also depends on the degree of income inequality in the society. A society with greater equality can expect to have a higher life expectancy because more people can afford life's necessities. Studies (Wilkinson 1992, 1994, 1996) have suggested that the beneficial effect of the absolute income becomes less important at higher income levels. Therefore, the distribution of income becomes more important in societies as incomes increase.

Wilkinson (1994) suggests that a country-to-country variation in life expectancy and infant mortality is frequently understood in terms of an epidemiological transition. This transition documents a given society's pathway to reduction of death rates, particularly those that are associated with communicable diseases. Demographic characteristics of a country that has yet to complete the epidemiological transition include high levels of mortality due to infectious diseases, high levels of fertility, and a predominantly young population that is especially vulnerable to infectious diseases. Once

the detrimental effects of communicable diseases are overcome by a society, mortality and fertility rates gradually decrease and stabilize the population ages and non-communicable diseases such as heart disease, stroke obesity, and cancer become more common as a cause of death.

Cross-Country Studies

Cross-country studies have played an important part in trying to unravel the relationship between income and health. Preston (1975) compared international patterns of GDP per capita and life expectancy and found that among the poorest countries, an increase in average income is strongly associated with an increase in life expectancy. However, as income increases, the relationship flattens out, and is often weaker or even absent among the richest countries. Higher incomes provide greater access to goods and services that promote health, including better nutrition, access to clean water, sanitation, housing and quality health care.

There are sound theoretical reasons for suggesting that inequality in the distribution of income matters for population health Proponents of the relative income hypothesis, such as Wilkinson (1992, 1994, 1996), suggest that cross-section evidence shows that population health declines when measured against income inequality, after allowing for the effect of per capita income and holding all else constant. Income inequality therefore leads to poorer health, which in turn decreases life expectancy. Using data from nine industrialized countries, Wilkinson demonstrates that countries with less income inequality seemed to have higher life expectancy. He interprets these results as showing that, as countries become wealthier and move through the

epidemiological transition, the leading causes of differences in mortality moves from material deprivation to social disadvantage. Therefore, at high per capita incomes, there is an independent effect of income distribution on the health of individuals.

Since Rodgers (1979), growing attention has been focused on the distribution of income in a society as an independent determinant of variation in life expectancy. Using data from 56 developed and developing countries from 1951-1969, including income distribution from Paukert (1973), Rodgers finds that there exists a robust statistical relationship between income inequality and indicators of population health such as life expectancy, infant mortality rates at birth, and childhood mortality rates at the international level. He mentions that improvements in health technology, education, sanitation, and a host of other variables as having undoubted effects on health. Rogers notes that empirically, the effects of these different factors are difficult to identify because the variables tend to be collinear with each other and with many other aspects of development, thus making their isolation difficult. He suggests that it is quite reasonable to propose a sequence of causation that goes from income to health via a number of intermediate variables. Rogers' results show that there is an independent effect of income distribution on health with a consistently significant coefficient.

Other writers have drawn conflicting conclusions about the effect of income inequality on health. Lately researchers have cast doubt on the reliability of the relative income hypothesis. Using the Deinenger and Squire data on income inequality for 75 countries between the periods of 1980-1990, Gravelle, Wilderman and Sutton (2000) fail to replicate the results of Rodgers paper. Whilst Rodgers found that the income distribution had a significant negative association with life expectancy in almost all his

regressions, they find that the association is sometimes positive, and sometimes negative, but never statistically significant in any of their models. They argue that one explanation for the difference between their results and those of Rogers is that the relationship between health, income and income distribution may have changed over time. Gravelle et al note that the aim of Rodgers research was to investigate the relationship between income and health, and not the effect of income inequality on health. They suggest that Rodgers used the Gini inequality measure as a means of dealing with the aggregation problem, not to test the relative income hypothesis.

Scully (2000) disagrees with Rogers and Wilkinson as well. In his paper, Scully examines the distribution of income without the effect of living in an improvished society. Using data from only 24 advanced countries with a per capita GDP of $7,500 or more, Scully observes that the level of per capita income is important to longevity but how it is distributed among the population does not matter, at least in high-income countries. He argues that although this finding shouldn't be surprising because in a democracy one must get a majority of the votes to get elected and stay in office. Since the majority of the population is usually the middle-class, most taxes and government expenditures are directed to them. Tax policy often serves as a means of redistribution via government expenditures.

Mellor and Milyo (2001) use a sample of 47 developing and developed countries in 1990 and find that the positive coefficient between the Gini coefficient and the infant mortality vanishes once secondary school enrollment is controlled for, while the negative correlation between income and inequality and life expectancy is eliminated by

controlling for income per capita. They also fail to replicate Wilkinson's result for developed countries.

Deaton (2001) singles out the work of Judge, Mulligan and Benzeval (1997) as being the most important and careful study of international comparison of the income-health relationship. Emphasizing the poor nature of data used by the previous studies, Judge et al. uses the Luxembourg Income Study (LIS), which is arguably one of the best international data currently available. The correlation between the Gini coefficient and life expectancy is –0.17, insignificantly different from zero. Neither the Gini nor any of the other measures of income inequality are significant in any of the regressions explaining life expectancy.

The situation is somewhat different for infant mortality rates, where Judge et al find a significantly positive (harmful) effect at the 90^{th} and 10^{th} percentiles. This measure of inequality exerts a significant effect on several of the regressions, though it becomes insignificant when controls are added for the negative effects on the mortality of female labor force participation rates. In this dataset, the correlation between infant mortality and inequality is driven largely by the US, which has a very unequal and a relatively high infant mortality rate. If these results are not entirely definitive, it may be because the LIS data, as good as it may be, is not fully comparable from country-to-county or fully accurate.

Kennedy and Kawachi (1997) test the sensitivity of various measures of inequality. They note that although the Gini coefficient is the most commonly used measure of inequality, it is more sensitive to inequality at the top of the income distribution. They also find that other measures of inequality such as the Theil measure

are quite sensitive to inequality at the bottom of the income distribution, while the Robin Hood Index usually known as the relative mean deviation, is unaffected by transfers between individuals on the same side of the mean. They test the relationship of six different inequality measures, and find that they are highly correlated with each other and are strongly associated with mortality. Therefore, the choice of income distribution measure does not appear to alter the conclusion that income inequality is linked to higher mortality.

Data

The basic criterion for including a country in the analysis was the availability of income distribution data. We conduct a cross-sectional study with life expectancy at birth being the dependent variable, while the Gini index and per capita GDP as the independent variables. Gross Domestic Product per capita -is the total monetary value of goods and service produced domestically in a country by both residents and non-residents, regardless of who receives the income, but excludes income earned by domestic residents on foreign ground- divided by the population.

Within the scope of this analysis, life expectancy is used to measure health and is taken from the *2001 World Development Indicators* published by the World Bank. Life expectancy is a generally accepted indicator of population health in light of the difficulties in determining, defining and gauging the concept of health (Wilkinson 1996).

Income inequality measure in the form of the Gini coefficient is drawn from the *2001 World development Indicators*. The Gini coefficient graphically illustrates the cumulative shares of income at successive income intervals. The value of the Gini index

falls between zero, which indicates perfect equality and one hundred, which indicates perfect inequality.

Methodology

We use a linear regression to convert a non-linear relation among the variables into linear relations among the transformations of those variables. In other words, life expectancy is regressed against the reciprocal of income (1/Y), and reciprocal of income squared ($1/Y^2$).

We replicate part of Rodgers paper and add a regional (continental) dummy variable to capture the variation in socioeconomic and environmental factors that result from living in different continents of the world. The aim of replicating the paper is to observe whether the use of a different dataset and time period will provide comparable results.

Rodgers original macro-model is specified as:

$$Y=a+f(X)+b(G)+\varepsilon$$

Where **Y = mortality or life expectancy**

f(X) = function of mean income

G = measure of income distribution

ε =error term **(Rodgers 1979)**

Rodgers favored the specification with the reciprocal of per capita GDP as an independent variable, rather than linear or logged income because the model with the reciprocal provided a reasonable asymptotic value; that is, a maximum life expectancy beyond which further increases in income had no further effect on health. (The asymptotic value is essentially the constant term in the reciprocal specification). The

reciprocal specification also had the highest adjusted R-squared and significant Gini coefficients. The specific model used by Rodgers that we replicate is:

$$L_k = \beta_0 + \beta_1 1/y_k + \beta_2 1/y^2_k + \beta_3 G_k + \varepsilon_k$$

Where L_k is life expectancy in country k

$1/y_k$ is the reciprocal of per capita GDP and $1/y^2_k$ is the reciprocal of the square of per GDP

G_k is the Gini coefficient

β_0 is the intercept

ε_k is an error term (Gravelle, Wilderman and Sutton, 2000)

The reciprocal of per capita GDP squared suggests that the relationship between income and life expectancy is non-linear. As income increases, the slope of the curve declines (at a declining rate).

Due to its broad range, it is likely the Gini index is a victim of non-constant variance in the error terms. Because heteroskedasticity is common in cross-sectional analysis like this and often arises when data exhibits a large range of observations, I correct for the lack of variance in the error terms of the regression using the White's Test for heteroskedasticity.

Results

(a) Replicating Rodgers Paper with a Different Dataset

Table 1 shows results from the Rodgers paper and the replication with a more recent data set. The significance of coefficients of equations 1 through 3 are more or less in line with Rodgers' previous findings even though different data sets and time period

were used. At first glance, the coefficients of the reciprocal of GDP per capita (1/Y) and GDP per capita squared ($1/Y^2$) may seem astronomically larger than Rodgers. This is because Rodgers used about half the number of countries and the GDP per capita from 1950-60s time period. Data used in the replication is from the 1990s and the GDP/capita is substantially higher than four decades earlier.

Table 1. Replication with a Different Dataset

Variable	*Rodgers (1979)*			*Replication*		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
1/Y	**-4469**	**-2236**	**-3389**	**-45311**	**-20817**	**-41980**
	(-6.4)	**(-12.11)**	**(-4.93)**	**(-13.14)**	**(-9.76)**	**(-10.68)**
$1/Y^2$	**149900**	**x**	**76880**	**15547542**	**x**	**13886349**
	(3.38)		**(1.74)**	**(7.59)**		**(6.26)**
Gini	**x**	**-0.44**	**-0.36**	**x**	**-0.23**	**-0.15**
		(-4.94)	**(-3.76)**		**(-3.27)**	**(-2.14)**
Constant	**72.9**	**73.7**	**75.1**	**78.1**	**82.5**	**83.1**
R^2 (adj)	**0.71**	**0.76**	**0.77**	**0.78**	**0.72**	**0.79**

	Rodgers (1979)	Replication
Sample size (countries):	56	111
Data sources:	Paukert (1973)	World Bank (2001)

Y is GDP per capita in US $
t-statistics are in brackets

There is an increase in the asymptotic value from the 75.1 in Rodgers (equation.3) to 83.1 in the replication (equation.3). This implies that a maximum life expectancy beyond which further increases in income had no further effect on health has increased over time. The Gini coefficients are significant in Rodgers as well as the replication, although the Gini coefficient in Rodgers is slightly higher than the replication. The Gini

is interpreted in the following way: A one unit increase in the Gini in Rodgers' equation 3, leads to a 0.36 unit decrease in life expectancy, while the similar replication will lead to a relatively lower 0.15 decrease in life expectancy. This essentially means that there was about twice more inequality in the 1950s than in the 1990s. Therefore, even though inequality is significant in both datasets, it has decreased over time. One argument that supports the decrease in inequality is the political system has changed between the two time periods from colonialism and democracies.

The coefficients of $1/Y$ and $1/Y^2$ can be interpreted to provide meaningful results as shown below:

Life Expectancy=$\beta 0+\beta 1\ (1/y) +\beta 2\ (1/y^2)+Gini+\varepsilon$
A one unit increase in income results in a change in life expectancy of approximately
Δ life expectancy$\approx (-\beta 1/y2)\Delta y + (-\beta 2/y3)\Delta y$
Example from the results table 1 column (3) above:
$\beta 1 = -\ 41980$
$\beta 2 = 13886349$
Average GDP/capita (y) from data =$8204
10% Change in y =$820.4
A 10% increase in average GDP per capita of $8204 will increase life expectancy by
Δ life expectancy $=[-(-41980)/(8204)^2]820.4 -[(2*13886349)/(8204)^3] *820.4 = 0.47$
Thus a 10% increase in average GDP/capita result in an increased average life expectancy of about half a year.

(b) <u>The Comparing the effect per Capita GDP and Gini Coefficient on Life Expectancy using Log-linear and Reciprocal Functional Forms</u>

As expected, the Gini index is negatively related to life expectancy and is significant when either the reciprocal or the log of GDP/capita is used (see table 2).

Table 2. Comparing the effect of per capita income and Gini Coefficient on Life Expectancy using the linear-log and reciprocal functional forms

Variable	*Reciprocal functional form*	*Linear-log functional form*	
1/Y	**-41980**	**Log (Y)**	**40.93**
	(-10.68)* **		**(6.93)*** **
$1/Y^2$	**13886349**	**$Log (Y)^2$**	**-1.95**
	(6.26)* **		**(-5.78)*** **
Gini	**-0.15**		**-0.14**
	(-2.14) **		**(-1.96)** **
Constant	**83.14**		**-133.34**
R^2 (adj)	**0.796**		**0.785**

*, **, *** Significant at 90, 95, 99 percent level
Sample size is 111
Data source: World Bank (2001)
Y is GDP per capita in US $
t-statistics are in brackets

The Gini coefficients in the two models are very similar (-0.15 and -0.14) and significant at the 95% level. The adjusted R^2 are almost identical too. Figure 1 below shows the association between the Gini index and life expectancy.

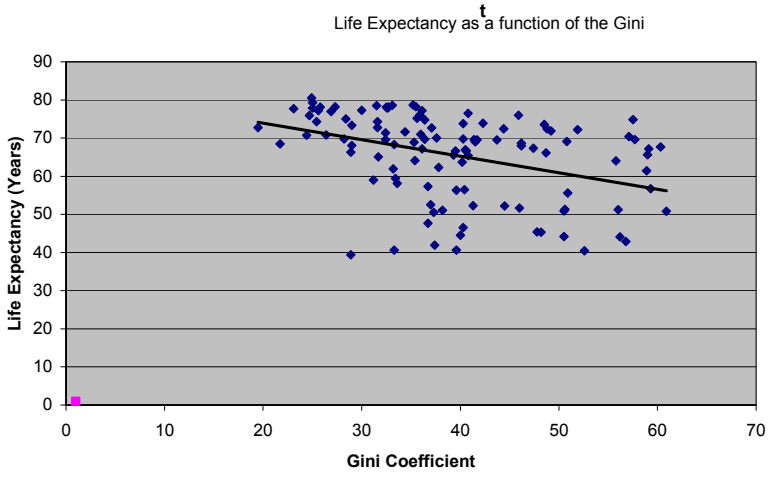


Figure 1 on page 13 shows the relationship between life expectancy and per capita GDP. Data Source : World Bank 2001.

The trend line shows that as inequality increases (shown by an increase in Gini coefficient), life expectancy decreases. This is consistent with the relative income hypothesis which suggests that the health of individuals in a society not only depends on per capita income but the distribution of income in a society matters as well.

(c) Extending Rodgers Model

We extend Rodgers model by including regional dummy variables because health is related to where one lives. Setting Africa as the basis of comparison, we find that living in any other continent has a positive and significant impact on life expectancy of between 6 to 12 years when compared to residing in Africa. This is clearly indicated in both the reciprocal and linear-log model as shown in table 3.

Table 3. Comparing Different Functional Forms and with the inclusion of Continental Dummy Variables

Variable	*Reciprocal functional form*		*Linear-Log Model*
1/Y	**-33933** **(-9.16)*****	**Log(Y)**	**19.4** **(2.57)****
1/Y2	**1.28e+07** **(6.82)*****	**Log(Y)^2**	**-0.795** **(-1.87)***
Gini	**-0.13** **(-1.91)***		**-0.12** **(-1.70)***
Europe	**9.2** **(4.11)*****		**9.06** **(3.76)*****
North America	**11.37** **(5.56)*****		**11.81** **(5.66)*****
South America	**9.99**		**10.89**

	(4.76)* **	**(5.06)*** **
Asia	**9.29**	**9.46**
	(5.23)* **	**(4.80)*** **
Oceania	**6.94**	**6.51**
	(1.65)	**(1.74)***
Constant	**72.65**	**-43.38**
R^2 (adj)	**0.878**	**0.874**

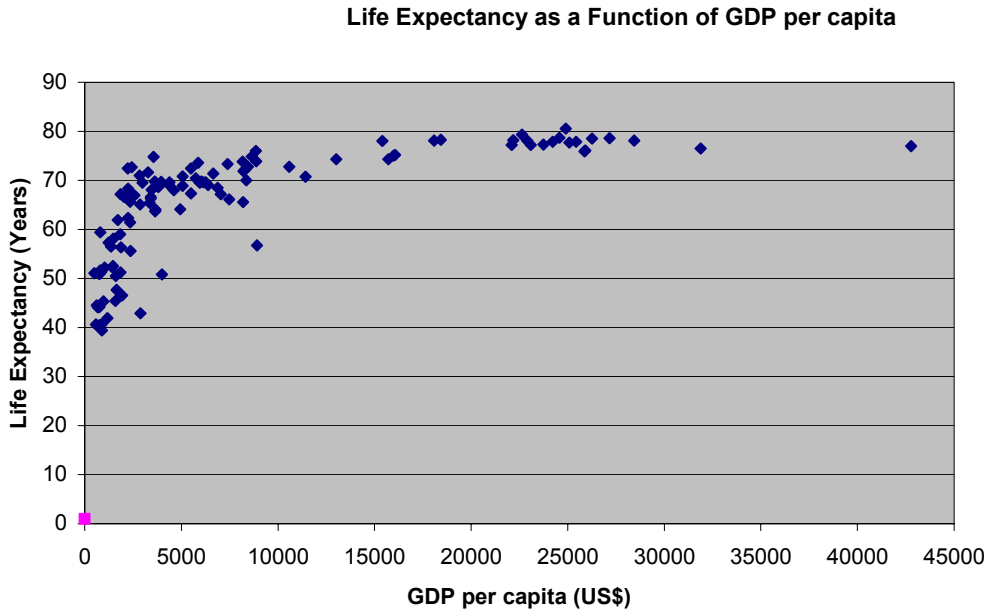
*, **, *** Significant at 90, 95, 99 percent level
Sample size is 111
Data source: World Bank (2001)
Y is GDP per capita in US $
t-statistics are in brackets

Broadly speaking, the African region is implicated in health in several ways. For example, the combination of tropical weather which tends to harbor and promote infectious diseases, economic underdevelopment, authoritarian regimes, civil and inter-state conflict, seriously challenge the population health of many countries in sub-Saharan Africa (WHO 1992). Such difficulties are not necessarily contained by international borders, but are better captured by a regional variable because they happen to be regional in nature and extent. Life expectancy in many African countries has declined due to Acquired Immune Deficiency Syndrome (AIDS).

Adding the regional variable to the regression reduces the significance in both the Gini coefficients and GDP/capita. The Gini coefficient significance drops from the 95% level to the 90% level. The values of the constant term in equations using the reciprocal of GDP per capita fall within a reasonable range of asymptotic value in all three tables. The percentage change in life expectancy explained by the changes in the explanatory variables increases to 0.88 when the regional dummy variables are added compared to 0.79 before the inclusion of the regional variables.

The figure 2 below shows the relationship between per capita GDP and life expectancy. On average people in poor countries have shorter lives than people in rich countries. We observe that the relationship between life expectancy at birth and average GDP per capita increases at a decreasing rate. There reaches a maximum level at which any further increase in income has no effect on life expectancy at about 80 years. This is consistent with the absolute income hypothesis which emphasizes that population health improves with average income, but at a decreasing rate.

Figure 2



Data Source: World Bank 2001.

(c) Using Infant Mortality Rates in place of Life Expectancy

Infant mortality is the number of deaths of infants under one year old in a given year per 1,000 live births in the same year. This rate is often used an indicator of the level of health in a country. Infants in poorer societies are more likely to die than their wealthier counterparts.

Table 4 shows the effect of per capita GDP and income inequality on life expectancy.

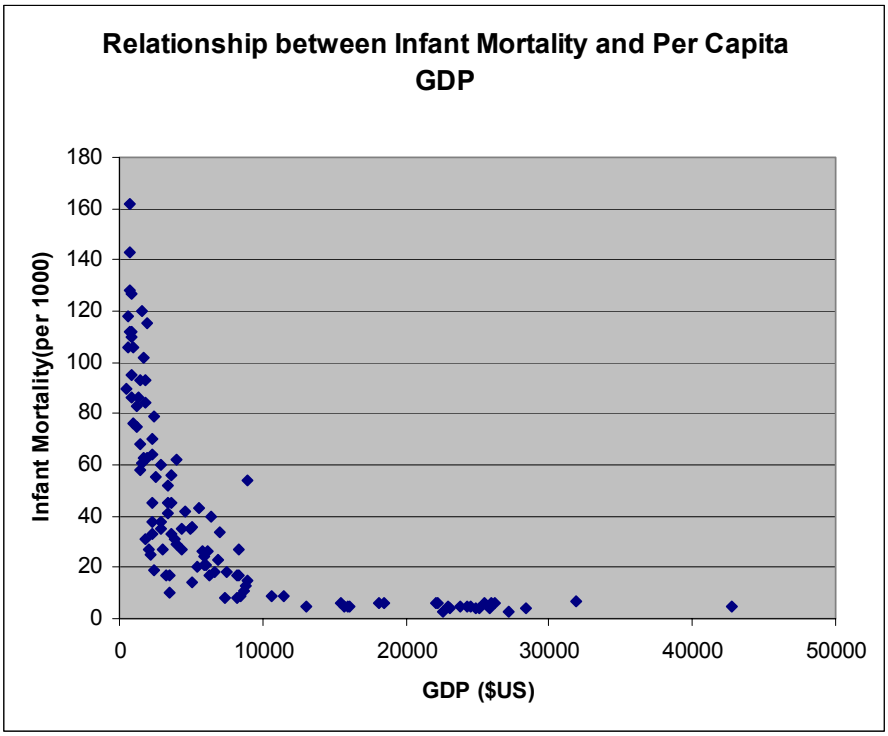
Table 4. The effect of per capita GDP and income inequality on infant mortality using the linear-log and reciprocal functional forms

Variable	*Reciprocal functional form*		*Linear-Log form*
1/Y	**143760**	**Log y**	**-178.19**
	(12.81)**		**(-8.69)*****
$1/Y^2$	**-45206483**	**$Log\ (y)^2$**	**8.91**
	(-6.48)***		**(7.31)*****
Gini	**0.42**		**0.48**
	(2.72)**		**(2.79)****
Constant	**-15.78**		**880.34**
R^2 (adj)	**0.84**		**0.83**

*, **, *** Significant at 90, 95, 99 percent level
Sample size is 111
Data source: World Bank (2001)
Y is GDP per capita in US $
t-statistics are in brackets

Using the reciprocal of income and its square together with Gini index, all three variables are significant at the 95% confidence level. Figure 3 on page 18 shows the relationship between infant mortality and per capita GDP. It's rather apparent that figure 3 is almost exactly the opposite of figure 2 which looks at the relationship between life expectancy and per capita GDP. This confirms the earlier argument that population health, whether measured positively by life expectancy or negatively by infant mortality, improves with average income, but at a decreasing rate.

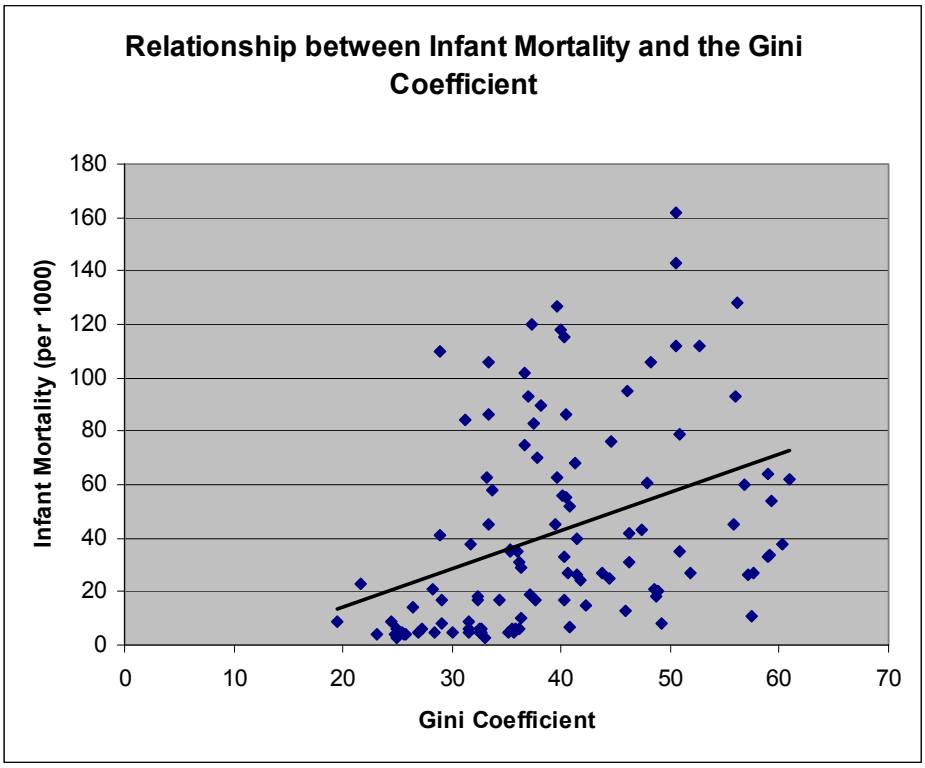
Figure 3



Data Source: World Bank 2001.

Societies with greater equality can be expected to have a lower infant mortality rate or higher life expectancy because more people can afford life's necessities. This is further confirmed by observing the trend line in figure 4 which looks at the effect of the Gini coefficient on infant mortality and comparing it with figure 1 which shows the relationship of the Gini coefficient and life expectancy. As income inequality increases, infant mortality rises, and life expectancy declines as indicated by the direction of the trend line in both graphs 1 and 4.

Figure 4



Data Source: World Bank 2001.

Caveats

Some authors such as Gravelle et al argue that there are serious methodological difficulties in using aggregate cross sectional data as a means of testing hypotheses about the effect of income and its distribution on the health because of the general assumption of the direction of causality as being from income to health, the reverse link is undoubtedly present. Therefore, using instrumental variables may be a more appropriate way of estimating the income-health relationship. Finding an appropriate instrument is proving to be a challenge that is yet to be overcome.

Why the differences in results among the various studies?

One plausible argument is the use different data sources, and time periods, which may have a profound effect on the results. International data on income inequality come from a number of standard sources. For example, to be included in the Deininger and Squire (DS) dataset, estimates have to come from an identifiable source, be national in coverage and be based on either consumption or income. The World Bank Living Standard Measurement Survey (LSMS) on the other hand, was set up in 1980 with the goal of generating comparable data on income distribution for a wide range of countries. While the LSMS surveys are broadly comparable, the questionnaires are not fully comparable across surveys. Perhaps the best is the Luxembourg Income study (LIS), which contains information on the distribution of disposable income for 25 wealthy countries over a period of 20 years. It is be worth noting that underlying surveys do not use the same questionnaires, so the comparability is not perfect, nor are response rates the same across countries. Nevertheless, the data is well-documented and has been widely analyzed, so that its properties are well understood. An obvious shortcoming with the LIS data is the lack of data from developing countries (Deaton 2001).

Conclusion

The results presented in this paper show that the relationship between life expectancy at birth and GDP per capital increases at a decreasing rate. There is a maximum life expectancy beyond which increases in income has no further effect on life expectancy. The diminishing rates of return to health with rising incomes imply that a redistribution of income from the rich to the poor will raise average life expectancy. It is

possible to argue that at very high incomes, diseconomies of excessive incomes may reduce life expectancy. Thus, an increase in absolute income does more for people at lower incomes than at higher. This finding is consistent with the absolute income hypothesis. If the rich get richer, their health will improve only slightly, whereas if the poor get poorer, their health may suffer greatly.

Given the same level of income, a more unequal society is likely to have greater numbers of people living in both absolute and relative poverty. The negative and significant coefficient on the Gini index in all the inverse and linear-log functional forms suggests that an increase in income inequality on life expectancy will worsens overall health. This is also evident with the direction of the trend lines in the graphs that look at the relationship between income inequality and life expectancy or infant mortality. Income inequality may therefore lead to poorer aggregate health, which in turn decreases life expectancy. The finding supports the relative income hypothesis which argues that the distribution of income matters for population health.

Policy Implication

Public action, often, but not exclusively by governments, can reduce material inequalities consequently increasing life expectancy. Examples of such action would include land redistribution, health care provision for the poor, subsidized food provision and progressive taxation. Due to lack of income in the hands of the poor means that they are unable to purchase medical care and other basic needs.

One of the few coherent arguments against redistributive social polices is that they hinder overall economic growth because the rewards offered to hard workers make

them even more successful. This in turn drives economic growth, which, through the trickle down effect, ultimately benefits the poor. Cross country comparisons, such as this paper, however seems to show the reverse.

Not only does income equality promote health because income does more for the wellbeing of the poor, but it also serves as a marker for other desirable features of a society. Wilkinson (1992) contends that equal societies have increased social cohesion, greater solidarity, and less stress, while offering their citizens more social support and increased social capital and that satisfy a humans being's evolved preference for fairness. Consequently, increasing equality will, among other things, raise life expectancy.

Economics is driven by the desire to enhance the utility of people. Easterlin (1974) found that the relative income of people in a society is the primary determinant of their "happiness". It is not quite clear whether perfect equality will lead to "optimum happiness" but egalitarians believe that by reducing inequality, one will be able to reduce the number of people that are unhappy in a society.

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