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EDUCATION AND MEDICINE AS HEALTH PRODUCERS

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Abstract:

We give a description of the production function of health in a country and survey the empirical studies that describe similar relationships. Our estimations are based on updated reports of life expectacy, GNP, literacy rate, physicians and hospital beds per capita. We also followed changes in the last seven years. We find the literacy raté to be statistically significant in prolonging life while the contribution of doctors and wealth is significant mainly in the less developed countries. The change along time is small but points to an increase in the production elasticity of medicine.

World Health Statistics; Life Expectacy; Literacy Rate.

In 1972 two basic and completely different papers studied theoretically and empirically the production of health. M. Grossman [1] presented the demand for health and based his empirical study on a cross section sample of workers in Chicago. T. Auster, I. Levenson and D. Sarachek [2] analysed the production functions of health and chose the fifty states of the U.S.A. as their data base. They used life expectacy as a measure for health. A stream of papers followed [3, 4, 5, 6, 7, 8, 9] using different countries of the world as a data base. This group of interesting papers lack a model which describes the main relationships between the measured variables. Our study adopts a more general attitude presented by P. Samuelson [10] and gives a basic model of health production in a country as a unit. We also give a more general empirical estimate for production of health in two periods: 1975-78 and 1981-85.

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The Model

In every country the physical and human capital produce welfare which includes goods, services and health. Let us use some notations to show the basic relationship in the economy.

K = the total capital of the country

Physical Capital
- Natural Resources
- Machines and Equipment
- Houses
- Hospital Beds = B

Human Capital
- Literacy Rate = R
- High School Graduates
- Physicians = D
- Nurses = N

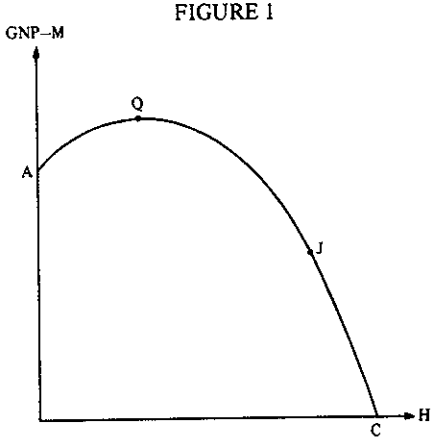
→ Net Economic Welfare (NEW) ⊃ GNP – M, Health = H

The country's total capital is employed in producing the welfare of the members of the economy. Two main components of a country's welfare are the Gross National Product and the good health of its citizens. Medical care denoted by M presents specific health services and is one of the inputs that produce health.

$$F = K - B - R - D - N$$

F measures the capital except for some special production factors measured separately. Similar to all consumption goods we see health as a goal of the economy and not just as a device to produce more income. Each economy chooses the components of GNP (food, housing, medical services, etc.) according to its preferences and distributes them in its own way. Our model refers to the components of the GNP-M and their distribution as exogenous.

FIGURE 1



In Figure 1 we describe a transformation curve AQJC which presents the possibilities of a country to obtain good health together with other goods and services. The line AQJC divides the plane between feasible and unfeasible "baskets", each containing different quantities of H and GNP–M. Each economy has its own transformation curve and chooses only one point on it. The whole line was drawn by economists [10] to present all alternative possibilities. The curve refers to the short time when the technology and the components of the total capital K are fixed. Rational economies will never choose a basket represented by the increasing interval AQ. Efficient points on the line QJC can be expressed by equation (1).

(1) $g(H, GNP–M) = K(F, R, D, N, B)$

We assume the function g in equation (1) is the same for all economies. The differences in the final quantities of GNP–M and H are explained by the quantities of available resources. An increase in resources or improved technology along time will shift the whole transformation curve upwards to the right.

We can isolate H from (1) and get equation (2).

(2) $H = f(GNP–M, F, R, D, N, B)$

We assume production function f is the same all over the world and would like to estimate it empirically. The main difficulty is the missing data about F. F was never estimated in numerical values. Its absence shifts the contribution, which in fact belongs to F, to other variables which are measured in the equation and are correlated with F. As GNP is mostly correlated with F, empirical estimates show a positive relationship between GNP and H. If we were able to control the capital stock F, it is not clear what would be the sign of the marginal effect of (GNP–M) on H. According to Figure 1, the relationship along the transformation curve AQJC is negative while differences in the wealth of countries are presented by shifts of the transformation curve and thus point to a positive relationship between (GNP–M) and H. Using GNP as a rough proxy to the two correlated variables F and GNP–M was the only possible solution. As each of the other variables R, D, N, B are less correlated with the missing variable F, we will get good estimations to their marginal products.

The Literature

Our presentation generalizes and updates several important and basic studies. Life expectancy is used as a measure for health, literacy rate serves as a proxy to schooling, and GNP as a proxy to capital F.

Isenman [6] estimated the equation:

(3) $\ln H = 2.83 + 0.065 \ln GNP + 0.199 \ln R \qquad R^2 = 0.88 \quad n = 59$
(45.3) (7.27) (10.69)

It was based on data around 1975. Medical services are omitted in this regression. O'Hara [7] explained how the omission of exogenous variables overstates the estimated

coefficients. Therefore we have to conclude that the coefficients estimated by Isenman were biased upwards.

Our model shows the importance of physicians, nurses and hospital beds. As they are positively correlated with GNP and R (as shown in Table 2) we will see that by including them in the equation both the coefficients of GNP and R get lower values compared to Isenman's estimates. It is also possible that the coefficients of GNP are lower because we estimated (3) in the year 1978, three years later than Isenman. Cochrane [4] showed how in a more recent period the elasticity of real income lowered. She pointed to the increase of GNP between the years 1975-1978.

Preston [8] calculated the influence of GNP on life expectancy in the years 1940 and 1970. As his database changed from 36 countries in 1940 to 120 countries in 1970, it is impossible to know whether the decrease of his coefficients of GNP is due to the addition of countries or due to the increase of GNP over a period of 30 years. Since the measures of per capita GNP used above are based on international exchange rates, which are subject to distortions, Preston [9] re-estimated the relationships using International Comparisons Project (ICP) measures of per capita GNP, which are based on purchasing power parities of various currencies. Estimating the life expectancy equation for 1965-69 and 1975-79 with both measures of income (together with literacy rate and excess calories availability) he finds that the coefficient of income in the ICP-based regressions is 50 per cent larger than that in the other regressions.

Chao [3], Hicks [5] and Wheeler [10] measured the effect of physicians on life expectancy. Chao based his analysis on 40 countries during the period 1960-1965. About half of these countries can be classified as developing countries. He found a significant effect of physicians on life expectancy.

Hicks [5] presented a more inclusive model of determinants of cross-national differences in life expectancy. His models include literacy, income and caloric consumption as well as several other variables which measure access to health care. This regression was calculated for 55 developing countries in the mid 1970's. His results show that literacy continues to be the most important variable and that the number of doctors is a statistically significant factor.

Wheeler [10] estimated the determinants of life expectancy by measuring the change between the years 1970-77 in 52 countries. He estimated the contribution of availability of medical personnel to life expectancy, but unfortunately his results are not always statistically significant.

J.R. Behrman and A.B. Deolalikan [12] analyze the effect of nutrition on health and survey the literature on this subject. They point to results of cross-country studies where the authors found strong per capita GNP effect on life expectancy in contrast to micro studies which showed weak household income effect on health demand. Our model shows that the cross-country regressions inexplicitly used GNP as a proxy to capital. They dealt with baskets of health and GNP as shown in Figure 1. Micro studies which mixed stocks and flows of wealth and health could not find a significant relationship, but studies which distinguished between stocks and flows, like Grossman [1], achieved satisfactory results. Cross-countries studies could use a proxy as they are based on averages which cancel random variety, but micro studies which try to explain the differences between individuals must use exact measures and very large samples in order to overcome the random variables that explain much of an individual's health given his background circumstances.

Research Design

Encouraged by the significant statistical results of these studies we designed a more general model which will present the basic relationships and use updated reports. Data was published by the United Nations [13], The World Bank [14] and The World Health Organization [15]. Following the literature we estimated the Cobb Douglas production function.

$$(5) \qquad H_i = T\,GNP_i^{\alpha_1} R_i^{\alpha_2} D_i^{\alpha_3} N_i^{\alpha_4} B_i^{\alpha_5} e^{u_i} \qquad i = 1, \ldots, 96$$

α_j denote the production elasticity of the various production factor
u_i denote the residuals from the production function (e = 2.71)

The coefficients detailed in Table 1 are the Least Squares estimates to the elasticities α_i.

TABLE 1

DETERMINANTS OF LIFE EXPECTANCY: LOGARITHMIC REGRESSION FUNCTIONS

Explanatory Variable	Life Expectancy in 1978				Life Expectancy in 1985			
	Year of Data	Countries with GNP < $ 1500	Countries with GNP > $ 1500	All Countries	Year of Data	Countries with GNP < $ 1500	Countries with GNP > $ 1500	All Countries
GNP (in US$) per capita	1978	0.036 (1.70)	0.010 (1.10)	0.023 (2.15)	1985	0.034 (1.17)	0.028 (4.0)	0.03 (3.1)
Adult Literacy (R) Rate	1975	0.105 (4.29)	0.294 (5.06)	0.108 (5.50)	1980	0.084 (3.45)	0.111 (4.32)	0.09 (5.36)
Physicians per capita (D)	1976	0.041 (2.35)	0.002 (0.70)	0.044 (3.46)	1981	0.050 (3.51)	0.017 (1.2)	0.04 (5.75)
Hospital Beds per capita (B)	1976	0.009 (0.55)	0.030 (1.25)	0.02 (1.75)	1981	0.018 (0.78)	0.014 (1.16)	0.010 (0.80)
n		61	35	96		46	38	84
R^2		0.78	0.80	0.89		0.70	0.78	0.89

Numbers in parentheses are t values.

Empirical Results

The regressions were calculated for two periods and for two groups of countries. In one group we gathered poor economies whose GNP per capita is less than $ 1,500 a year and in the other group economies whose GNP is higher than that. We also calculated the equations for all the countries together.

The coefficients support the existing knowledge about the decreasing marginal effect of wealth. Since GNP is used by us as a proxy for capital, estimates may be misspecified. Despite the difficulties, they show the positive but decreasing effect of wealth on health.

The main aim of the equations is to distinguish between the contribution of general wealth to health and the specific contribution of doctors. The regression coefficients presented in Table 1 already take care of the covariance between GNP per capita and doctors per capita (as detailed in Table 2).

TABLE 2

CORRELATION COEFFICIENTS (1981-1985, n = 84; ALL VARIABLES ARE IN NATURAL LOGARITHMS)

	GNP	R	D
R	0.696		
D	0.846	0.755	
B	0.805	0.721	0.758

The insignificance of some of the coefficients was probably caused by the covariance. The production elasticity of doctors per capita was significantly positive only when the less developed economies were included in the regression. It was also found that their production elasticity was higher than the elasticity of GNP per capita. This result was expected as specialized resources were expected to have higher marginal productivity than general wealth. GNP serves as a proxy for both F and (GNP–M). We expected (GNP–M) to be negatively correlated with H. Therefore the coefficient of GNP as the only variable cannot be too high. By considering the coefficients when the regression is run for poor countries as compared to when it is run for richer countries we learn that the marginal product of doctors decreases as their number increases. During the seven years that passed between 1978 and 1985 the marginal product of doctors increased. This rise can be explained by tecnological improvement and by the growth of other factors such as wealth and schooling, which help doctors to obtain higher production for the same input. Although the quality of doctors varies over the world, this variation does not bias our estimators as quality is not correlated with quantity. Let us have a brief look at the data of doctors per capita (10,000): Argentina 20.0, Italy 20.5, U.K. 13,1, U.S.A. 16,8, USSR 33.7. Literacy rate has the highest production elasticity, and the coefficients are statistically significant for all groups of countries. Along time the elasticity declines due to the increase of literacy rate. The attribute of hospital beds is not statistically significant, but, on the other hand, its positive contribution cannot be ignored. The variety of the quality of doctors and hospital beds between countries and the variety of the relative prices of doctors and beds prevent us from estimating a compound index of both variables. The variable nurses was omitted due to missing data in some countries. All R^2 (multiple coefficients of determination) point to a good fit of the data to equation (5).

Conclusions

The coefficients we found go along with estimates of health production factors in the U.S.A. [1, 2], but countries that want to prolong life expectancy and look for a formula to allocate their scarce resources should not hurry to adopt the equations presented in Table 1. Our research indicates that the optimal way to improve health does not necessarily lead to increased medical expenses. One should investigate the possibility of spending more on education and study carefully relationships in one's own country.

A local production function of health should be estimated before planning social services. Estimations should be based on cross-section data like those done by Grossman [1] and Machnes [16]. Acquaintance with the local production elasticities and relative prices will improve allocation of resources in order to produce more health in the long run.

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