PRODUCTION RELATIONSHIPS BETWEEN VARIOUS INDEXES OF MORTALITY AND INCOME EDUCATION HEALTH SERVICES AND OTHER ENVIROMENTAL VARIABLES.

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1. Introduction

This paper focusses upon the formulation of a model which presents some aspects of the existing relationship, between various indexes of mortality (e.g. infant, neonatal, post neonatal, still birth, and crude mortality), and some other environmental and medical service variables. The empirical investigation is based on time series data[1] for the period 1958-1975.

Due to the small number of observations (only 26) we will not be able to include many environmental nad medical service variables and therefore the number of independent variables will remain as limited as possible.

2. The model.

IN our analysis, by considering mortality as a health status indicator, we will see that health services are not the only contributors to the reduction of mortality and more generally to health improvements within a population. Many other factors related to environmental conditions and to the «way of life» in general e.g. exercise, drinking habits, smoking, diet. etc. have an important effect upon health status. It

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1. The data used in this section have been collected from three different sources. (i) The output data was collected from: *Natural Movements of the Greek population.* National Statistical Service of Greece. (ii) The education variable was estimated from: *Staistical Yearbook of Greece.* National Statistical Service of Greece.
(iii) All the input variables were estimated from: *National Accounts of Greece. Years 1958-1975.* Ministry of Co-ordination. Athens.

could be claimed that changes in these environmental factors (non-medical determinants of mortality) may have a greater impact on mortality rates than the effects of medical services. This section will be addressed to the study of this hypothesis.

Recent literature in the field of health economics by Fuchs V. (1974), Cochrane (1972), (1978), Illich (1976), Somers (1973), Auster et al. (1969) seems to reflect a growing willingness to admit thtat the health status of a region (measured in mortality terms) may not be improved simply by increasing the quantity of health resources.

Fuchs[2] (1974) in particular states:
«Today ... differences in health levels between the U.S.A. and other developed countries ... are not primarily related to differences in the quantity and quality of medical care. Rather they are atttributable to genetic and environmental factors and personal behaviour. (Fuchs 1974, p.6).

Similarly to Fuchs, Auster[3] et al. 1969 using U.S.A. data found that:
«The age-adjusted death rate has not declined appreciably between about 1955 and 1965 ... in spite of a substantial increase in the quantity of medical services produced per cvapita, and probably some technological change as well.»
(Auster R. et al. (1969) p.153).

Also Cochrane A.[4] et al. (1978) by using data from 18 countries found that:
«The correlation between prevelence of doctors nad paediatricians and mortality is large and positive in the younger age groups, it is positive in young adult life, and it only becomes negative in the two oldest age groups.
(Cochrane A., et al. (1978) p. 201).

Given the above evidence supporting a more minor role for the health services in the improvement of health status, in the rest of this section we will specify a model for investigating the relationship between mortality, health services and other environmental variables.

Two basic assumptions are involved in our model:

1st Assumption. This assumption implies that the level of health status is viewed as a result of two basic actions:
(α) The amount of medical services consumed by the population and

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2. Fuchs V. (1974) *Who shall live*. Basic Books, New York.

3. Auster R. Laveson I. Sarachek D. (1969) The production of Health. An exploratory study. *Journal of Human Resources*. 4. Fall 1969. pp. 412-436

4. Cochrane A.L. Leger A. and Moore, F. (1978) Health Service Input and mortlity output in developed countries. *Journal of Epidemiology and community health*, vol. 32. pp. 200-205.

(b) The environmental factors. This comprise the social, economic and physical surroundings of a unit of population which are outside the medical care system. All these factors will be considered as exogeneously determined.

2nd Assumption. This assumption implies that the level of medical care consumption is endogenous. This means that health status is not only defined as a causal result of medical care but that there is a simultaneous relationship between health status and medical care. The above assumptions imply the formalisation of the following simultaneous equation medel..

$HS_k = F\ [(x_1\ x_2\ x_3\ ...\ x_n)\ ;\ (E_1\ E_2\ E_3\ ....\ E_m)]$

$X_1 = G_1\ (HS_1\ HS_2\ HS_3\ ....\ HS_k)$

$X_2 = G_2\ (HS_1\ HS_2\ HS_3\ ....\ HS_k)$

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$X_n = G_n\ (HS_1\ HS_2\ HS_3\ ....\ HS_k)$

where HS_k denotes different types of k health status for the current year.

X denotes the n types of medical services provided in a population.

E denotes the m types of environmental variables.

In the present section we will specify defferent stochastic formulations for estimating the above model.

If we use ordinary (single-equation) least squares estimations for calculating the parameters of the first equation (production relationship), we will ignore the simultaneous aspects between medical care and health status and the result will be simultaneous equation bias (Marshack and Andrews (1944) Nerlove (1965)). In order to eliminate this problem from our analysis we will use the two stages least square techique (Johnston (1972), Theil (1971)). Here we will use a Cobb-Douglas production function for estimating the impact of environmental and other medical variables upon the level of health status.

In summary the proposed model, in its explicit form, along with the expected signs of the partial derivatives may be written as follows:

$$Mi\ {}^{1}{}_{8}\ F\ (Alc,\ Cgc,\ Foc,\ Hec,\ Ed,\ Ye,)$$

$$\frac{\Delta M}{\Delta Yc} < 0\ ;\quad \frac{\Delta M}{\Delta Alc} > 0\ ;\quad \frac{\Delta M}{\Delta Cgc} > 0\ ;$$

$$\frac{\Delta M}{\Delta Foc} \lesseqgtr 0 \; ; \quad \frac{\Delta M}{\Delta Hec} < 0 \; ; \quad \frac{\Delta M}{\Delta Ed} < 0 \; ;$$

Where Mi denotes the mortality index (infant, neonatal, post neonatal, still birth, crude mortality).

Yc denotes Income per capita.

Alc denotes Alcohol consuption per capita.

Cgc denotes cigarette expenditures per capita.

Foc denotes Food expenditures per capita.

Hec denotes Health service expenditures per capita.

Ed denotes proportion of the people with first and secondary education.

3. The Results

At the beginning the estimation of the proposed model will be carried out by applying the ordinary least squares method to the logarithms of output and inputs. This formulation (Cobb-Douglas function) has the advantage of providing us with readily identifiable parameters, which present the percentage change in mortality indicators resulting from a one percentage change in one independent variable. The results of the estimation procedures are displayed on table 1. For each of the alternative specifications (excluding the neonatal) there is a regression explaining 84 to 99 per cent of the mortality variation through time. As it is postulated by the high degree of the coefficient of determination (R^2) one of the main problems with which we are confronted in our analysis is the high degree of multicolinearity existing between the indeprendent variables (vectors). Since income and the other environmental variables are highly correlated (see Corelation matrix between independent variables table 2), we experiment whith defferent spicifications by including income in some regressions and excluding it from some others. However even with these specifications the problem of multicolinearity still existed.

In order to correct the autocorrelation error in the random variable U, for every defferent production specification we applied the Cochrane-Orcutt[5] iterative technique (1949). As is indicated by the values of the Durbin-Watson test, in most of the cases, the Cochrane-Orcutt technique has reduced the autoregressive error and it has

5. Cochrane D. and Orcutt G.H. (1949) «Application of least squares regressions to relationships containing autocorrelated error terms». Journal of the American Statistical Association Vol. 44. pp. 32-61.

table 1

Time Series – Cobb-Douglas Production Function. Ordinary Least Squares and Cochrane-Orcutt Technique.

	INDEPENDENT VARIABLES										
	Income	Alcohol									
Dependent Variable	Income	Alcohol	Tobacco	Health Expend	Food Expend	Education	Constant		F_{test}	R^2	D.W.
Infant Mor.	−0.11	−0.32	−0.11	−0.12	0.66	−0.21	3.97		30.01	0.90	1.78
	(−0.23)	(−1.51)	(−0.29)	(−0.86)	(1.03)	(−0.77)	(8.25)		(6.19)		
Infant Mor.	−0.17	−0.14	−0.31	−0.02)	1.16	−0.56	3.91	C.O.R.C*	94.43	0.97	2.24
	(−0.68)	(−1.15)	(−1.38)	(−0.24)	(3.26)	(−3.61)	(14.97)		(6.18)		
Neonat. Mor	−0.20	−0.13	−0.24	0.19	0.19	0.07	3.39		3.43	0.52	0.72
	(−0.37)	(−0.56)	(−0.54)	(1.20)	(0.26)	(0.22)	(6.20)		(6.19)		
Neonat. Mor	−0.19	−0.12	−0.09	0.03	0.55	−0.11	3.05	C.O.R.C*	7.05	0.70	2.34
	(−0.39)	(−0.66)	(−0.25)	(0.19)	(0.92)	(−0.43)	(5.33)		(6.18)		
Post-Neo. Mor.	−0.67	−0.36	−0.33	−0.15	1.25	−0.49	4.87		294.70	0.98	2.43
	(−1.60)	(−1.93)	(−0.92)	(−1.25)	(2.19)	(−2.00)	(11.37)		(6.19)		
Post-Neo. Mor.	−0.64	−0.41	−0.28	−0.07	1.28	−0.65	4.96	C.O.R.C*	336.29	0.99	2.07
	(−2.01)	(−2.57)	(−0.99)	(−0.81)	(2.82)	(−3.29)	(14.79)		(6.18)		
Stillbir. Mor	0.53	−0.61	0.12	−0.26	0.53	−0.11	1.33		19.19	0.86	1.80
	(1.40)	(−3.64)	(0.39)	(−2.37)	(1.05)	(−0.50)	(3.50)		(6.19)		
Stillbir. Mor	0.49	−0.56	0.10	−0.26	0.48	−0.05	1.40	C.O.R.C*	15.55	0.84	1.97
	(1.17)	(−3.12)	(0.30)	(−2.09)	(0.86)	(−0.20)	(3.40)		(6.18)		
(8)											
Crude Mort.	0.27	0.11	−0.18	−0.06	−0.04	0.07	1.37		26.42	0.89	1.94
	(1.39)	(1.21)	(−1.09)	(−1.14)	(−0.15)	(0.62)	(6.87)		(6.19)		
Crude Mort.	0.28	0.08	−0.16	−0.07	−0.09	0.10	1.37	C.O.R.C*	24.51	0.89	2.00
	(1.43)	(0.91)	(−1.00)	(−1.27)	(−0.32)	(0.86)	(6.84)		(6.18)		
(8)											

* The method of Cochrane-Orcutt Technique has been applied t – ratios in parenthsis

TABLE 2

Output Correlation Matrix

	infant	νεον	post-NEON	STILL BIR.
INFANT	1			
NEONATAL	0.56	1		
POST-NEONATAL	0.90	071	1	
STILL-BIRTHS	−0.13	−0.39	−0.44	1
CRUDE-MORTAL	−0.85	−0.55	−0.92	0.32

Input Correlation-Matrix

	INC.	ALC.	TOB.	FOOD	H.S.	H.E.	ED.	G.D.P.
INCOME	1							
ALCOHOL	0.95	1						
TABACCO	0.99	0.97	1					
FOOD	0.98	0.91	0.97	1				
HEALTH SERV.	0.98	0.89	0.96	0.99	1			
HEALTH EXPEND.	0.97	0.96	0.97	0.95	0.94	1		
EDUCATION	0.98	0.97	0.99	0.98	0.96	0.97	1	
G.D.P.	0.999	0.96	0.99	0.99	0.98	0.97	0.99	1

also improved the R^2 values, as well as the F test values showing that this procedure provided an improvement to the fitting of the regression.

In almost all specifications (see table 1) it was found that the impact of medical services, (measured in terms of health expenditures per capita) on infant, post neonatal, still-birth and crude mortality trends, were much smaller in relation to the impact of income, tobacco, food expenditures, alcohol consumption and education. This finding justifies the theory proposed by Fuchs (1974), Mckeown (1971), Illich (1976), Somers (1973), Cochrane (1972) (1978), and others that medical services have a smaller impact on mortality trends than other environmental variables.

From all the non-medical variables, income per capita and the education variable, provided us with the expected negative signs. In some cases, as, is indicated by the t-values, the esimated coefficients of these variables were found to be significant at an $\alpha=0.01$ statistical level. Alcohol consumption and tobacco consumption surprisingly provided a negative signs. Obviously a better less aggregated specification of these variables may provide some improved results.

In order to assess the simultaneous determination between health status and medical care we estimated a model based on the two-stages least squares technique. The results for different spicifications of these models are shown on table 3. In order to eliminate the autoregressive error we applied the Cochrane-Orcutt technique once more in the two-stages least squares model. As is indicated by the Durbin-Watson values the autoregressive error is eliminated. The specified models can explain 80 to 99 per cent of the variance of the mortality trends and once more the F test values shows a relatively good fit and a rejection of the null hypothesis that ($R^2=0$), (at an $\alpha=0.01$ statistical level). The results of the two stage least squares models show once more that the impact of health services[6] on mortality trends is relatively smaller with

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6. As it can be seen from table 3 in order to study the impact of health services upon defferent mortality indexes we used two defferent variables. The first one is health expenditures per capita and the second is the value-added output of health services measured in monetary units. As can be seen from table 3 the value added index for health services, provided in most cases a positive sigh. In order to test whether this is attributed to just multicolinearity problems we regress infant mortality, still births, and crude mortlity against value added health services. The results of these specifications are as follow:

$$\text{Inl} = \underset{(49.49)}{4.17} - \underset{(-7.46)}{0.49}\ \text{HSEL} \qquad R^2=0.70 \qquad F=55.61$$

$$\text{Stl} = \underset{(27.6)}{2.32} + \underset{(3.16)}{0.21}\ \text{HSEL} \qquad R^2=0.29 \qquad F=9.99$$

$$\text{CML} = \underset{(76.8)}{1.79} + \underset{(11.6)}{0.21}\ \text{HSEL} \qquad R^2=0.85 \qquad F=135.28$$

Where HSEL = logarith of health services.
Inl = infant mortality (Logarithm).
Stl = still births (Logarithm).
CML = crude mortlity (Logarithm).
t-values in parenthsis.

TABLE 3

Time-Series Cobb-Douglas Production Function
Two-Stages Least Squares Estimations Including the Cochrane-Orcutt Iterative Procedure

Depend. Variab / Indep. Variab	Infant Mortality		Neonat. Mortal.		Post-Neonat. Mortality		Still-births Mortality		Crude Mortality
Income	−0.12	−0.25	−0.25	1.14	−0.74	−0.43	0.59	−0.88	0.079
	(−0.43)	(−0.43	(−0.39	(1.03)	(−2.03)	−0.40)	1.11	(−1.78)	0.19)
Alcohol	−0.09	−0.16	−0.20	−0.31	−0.53	−0.55	−0.49	−0.55	0.058
	(−0.62)	(−1.08)	(−0.79)	(−1.01)	−2.44)	(−1.98)	(−2.09)	(−4.13)	(0.53)
Tobacco	−0.35	−0.29	0.09	−0.13	−0.19	−0.17	0.0006	0.11	−0.14
	(−1.43)	(−1.27)	(0.18)	(0.23)	(−0.57)	(−0.44	(0.002)	(0.46)	(−0.76)
Food cons.	1.15	1.02	0.027	1.53	1.21	1.15	0.33	−0.50	−0.20
	(3.12)	(2.45)	(0.04)	(1.06)	(2.46)	(1.81)	(0.49)	(−0.87)	(−0.51)
Education	−0.53	−0.50	−0.32	−0.35	−0.64	−0.70	0.28	0.35	0.15
	(−3.25)	(−1.74)	(−0.77)	(−0.63)	(−2.96)	(−1.37)	(0.87)	(1.42)	(0.70)
Constant	3.81	4.10	3.89	0.63	5.19	4.84	1.11	3.89	1.74
	(11.57)	(5.18)	(4.30)	(0.32)	(11.47)	(3.52	(1.77)	(4.69)	(2.79)
Health Exp.*	−0.085		0.41		0.053		−0.52		
per capita	(−0.65)		(1.07)		(0.32)		(−1.80)		
Health Serv.*	0.11		−2.07		−0.24		1.75	0. 20	
		(0.17)		(−1.37)		(−0.22)		(2.74)	(0.41)
R^2 Stat.	0.97	0.973	0.59	0.29	0.99	0.80	0.92	0. 88	
F test	90.22	10766	4.37	1.23	301.26	270.24	11.92	34.36	21.20
	(6.18)	(6.18)	(6.18)	(6.18)	(6.18)	(6.18)	(6.18)	(6.18)	(6.18)
Durbin Watson	2.16	2.29	2.11	1.94	2.07	2.13	1.84	1.79	1.88

t-ratios in parenthsis
* Endogenously estimated.

regard to the environmental variables. Also income and education provided a negative coefficient showing, in some cases (especially in the case of infant mortality and post-neonatal mortality), that a 10 per cent increase in income would reduce, by more than 2.5 per cent infant and by 7 cent post-neonatal, mortality. Also a 10 per cent increase in the education level would reduce, by more than 5% infant and by 6% post-neonatal mortality.

4. Conclusions

Concluding this section we have to remark upon the limitations of our model which derive from the limeted statistical observations, as well as the deficiencies with regard to health status indicators (in particular the deficiencies of the obtained data for neonatal mortality[6] and the lack of age and sex adjustment for the Grude mortality).

The unidimensionality of mortality data presents a serious inability to explain the multidimensional aspects of health. The health status of a nation or a region should be measured by a more detailed model which will include information regarding not

7. See Urban Rural Population, National Statistical Service of Greece (1974)

only mortality but also morbility states e.g. pain, suffering physical and emotional stress etc. The level of Health in such a model, should be conceptualised as ranging over a continum with perfect at one end and death at the other. (For the specification of such a model see Yfantopoulos 1979α, 1979b).

However, despite the above difficulties our model did provide some usefull information concerning the negative association between income and most mortality indicators, as well as heath expenditures education and mortality data. It was also provided some evidence for supporting the hypothesis that the Greek infant mortality trends are influenced to a larger extent from the level of economic prespetiy and the level of education and to a smaller extent from the amount of health expenditures. Obviously further research is required in this area for a better specification of the production relationship between health status and medical, environmental, demographic and sociological variables. In addition more detailed indexes should be spicified which better reflect the actual medical and environmental conditions where the health production process is located.

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