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ECONOMIC DEVELOPMENT, INFANT MORTALITY, AND THEIR DYNAMICS IN LATIN AMERICA

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ABSTRACT

The main issue of this paper is to study infant mortality in Latin America in recent decades. In so doing, two questions must be answered: First, how large is the economic loss in terms of net national product due to child mortality under the age of 15 and what are the major causes of death? Second, has the decline of infant mortality been principally a product of economic development in Latin American countries?

Surprisingly enough, there is significant variation of economic losses across Latin American countries, such as from 0.99% of the net national product in Uruguay to 18.93% in Haiti. Eleven among the nineteen countries in Latin America show their economic losses to be more than 3% of the net national product in recent years in marked contrast to those values found by Kuznets (1980) for Egypt (2.68%) and the Netherlands (0.17%) in 1937. As the major causes of death in Latin America, these diseases -- influenza and pneumonia, enteritis and other diarrheal diseases, and other infective and parasitic diseases -- account for one-third or more of total deaths for many Latin American countries. Being provided with the fact that the proportion of infant mortality only is roughly about 20 - 30% of total deaths across the countries, we speculate that these above diseases will be exclusively responsible for the high mortality in childhood in Latin America.

The Granger-Sims dynamic system shows that economic development in Latin America does not have strong explanatory power in accounting for the behavior of infant mortality rate in recent decades. Therefore, the empirical results seem to support the view that medical and health technological development is the major cause of the reduction in infant mortality rates in Latin American countries in recent decades. However, when economic development Granger-causes infant mortality as observed for only two countries, the former becomes the main source of variation of the latter over long horizons.

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ECONOMIC DEVELOPMENT, INFANT MORTALITY, AND THEIR DYNAMICS IN LATIN AMERICA

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During the 1930s through 1950s, the average life expectancy at birth in Latin America substantially increased from 32.8 to 55.1 years due to the unprecendented decline of mortality rates.[1] Despite the reduction in the latter, the birth rates have not been so responsive that the population trends in Latin American countries are characterized by high rates of population growth, e.g., 2.5% per annum or more (see Table 10 in appendix).

As for the economic development in Latin America, the 2.5% of population growth per annum normally requires a high rate of annual capital investment, e.g., 7.5% of the national income, to keep real per capita income constant, when the capital-output ratio is assumed to be 3, as in other less developed countries (Notestein 1966). However, the high rate of annual capital investment is often hindered by the large proportion of children under 15 years old in Latin America, e.g., about 45% of total population (see Table 10: P0-14). The large proportion of children usually implies more consumption and less capital investment of national income, which leads to lower economic growth than otherwise.

Demographers often attribute the causes of mortality reduction in less developed countries (LDCs) to medical and health technological development imported from more developed countries (MDCs), which is considered independent of economic development in the case of Latin America (Arriaga and Davis 1969). On the other hand, some international cross-sectional studies show that 20 to 50% of the gain in life expectancy at birth between 1940 and 1970 results from the changes in per capita income in LDCs and MDCs (Preston 1975 and 1980). Along the same line as Preston, Fuchs (1980) finds almost 30% of the observed change in life expectancy at birth in LDCs attributable to the growth of per capita income during the period of 1940 through 1970. Therefore, this paper reexamine the question of whether economic development has any power to explain infant mortality behavior in Latin America by using time-series causality techniques developed by Granger and Sims. The importance of such a study is underscored by Preston (1980), who states: "Considerable dispute remains about whether the decline [of mortality] has been principally a by-product of social and economic development ... or whether it was primarily produced by social policy measures with an unprecendented scope or efficacy."[2]

The intent of this paper is, first, to calculate economic loss due to child mortality under the age of 15 by using the Kuznets method (1980), and, second, to examine whether the decline of infant mortality has been principally a product of economic development in Latin American countries. The rationale for using the infant mortality rate rather than life expectancy at birth in this time-series analysis is : As mortality rates have declined in Latin America in recent decades, the infant mortality rate has become one of the predominant rates in determining the life expectancy at birth.

Section I illustrates the calculation of economic loss and the results in addition to the data for the major causes of death and medical aspects in Latin America. Section II describes briefly the statistical techniques to observe dynamic relationships among variables, i.e., infant mortality rate, birth rate, and real per capita income (as a proxy variable for economic development). Section III reports the empirical results. Finally, section IV gives a summary of the findings of this study.

I. CAUSES OF MORTALITY, MEDICAL ASPECTS, AND ECONOMIC LOSS

The purpose of this section is to facilitate the understanding of current demographic situations in Latin America, focusing in particular on the economic loss due to child mortality under the age of 15. Although the topics in this section are related to the primary question in this paper about whether the decline of infant mortality has been principally a product of economic development in Latin America, it may be appropritate to treat this section as independent of the following sections II and III.

Despite the dramatic decline in infant mortality in Latin American countries in recent decades, the current rate of infant mortality is still surprisingly high -- 20 points or more per thousand live births above the infant mortality rate in the United States in 1975 (see INF1975 in Table 10). In order to explain the reasons for the high infant mortality rate, it is necessary to investigate the causes of death. Table 11 in appendix show the proportions of major causes of the total deaths in the country. The listed causes of death give valuable information about the causes of infant mortality because the proportion of infant mortality accounts for 20 - 30% of total deaths in Latin American countries (see INFD/TD in Table 10).

Compared with the causes of death in the United States, the proportion of heart diseases is substantially lower in Latin American countries, probably because of their diet (see Table 11).

On the other hand, the proportions of the last three groups of diseases in the table -- influenza and pneumonia, enteritis and other diarrheal diseases, and other infective and parasitic diseases -- are much higher than those proportions in the United States and may bear exclusive responsibility for the high infant mortality rate in the Latin American countries. The influenza and pneumonia explains the roughly more than 10% of total deaths for Guatemala (15.7%), Mexico (13.1%), Chile (9.7%), Ecuador (9.5%), and Peru (20.5%). Also, 12 - 18% of total deaths are caused by enteritis and other diarrheal diseases for El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Ecuador, and Peru. In addtion, other infective and parasitic diseases constitute a significant proportion of total deaths for Guatemala (20.5%), Honduras (10.0%), Ecuador (13.2%), and Peru (12.1%). Consequently, these three groups of diseases -- influenza and pneumonia, enteritis and other diarrheal diseases, and other infective and parasitic diseases -- account for one-third or more of total deaths for the following countries: Guatemala (54.5%), Honduras (28.5%), Mexico (32.0%), Nicaragua (30.4%), Ecuador (34.6%), and Peru (44.2%) when we add the figures of different years as an approximation. As Preston (1980) describes, these diseases will be prevented by immunization, identification and isolation, purification and increased supply of water, sewage disposal, and personal sanitation. Antibiotics, chemotherapy, and rehydration are the major medical treatments.

Table 12 includes information on medical aspects in Latin American countries -- the number of hospital beds per thousand population in each country and the number of inhabitants per medical doctor in cities with over 100,000 population as well as in each country. As we note, all countries except Argentina (5.4 beds) and Uruguay (5.7 beds) have 4 beds or fewer per thousand population. The number of beds in Haiti in 1976 shows a surprisingly small figure -- 0.8 beds per thousand population in contrast to 6.3 beds in the United States in 1977.

Medical doctors, i.e., physicians, are heavily distributed in cities with over 100,000 population, relative to rural areas.[3] The average number of inhabitants per doctor in the cities is 861 (not shown in Table 12) in the period of 1968-1971, while the average overall of country is 2,877 (also not shown in the table).[4] The figures in Haiti present the most strikingly unequal distribution of doctors such that the number of inhabitants per doctor in the cities and in the country as a whole are 1,382 and 15,750, respectively. The ratio of 15,750 to 1,382 is 11.4, which is listed in the last column in Table 12. This value means that the inhabitants in rural areas are at least 11.4 times more difficult to reach with medical services than the inhabitants in cities with over 100,000 population. This unequal distribution of medical services seems to explain partially why infant mortality risk is much higher in rural areas than in urban areas in Latin America.[5]

We speculated earlier about influenza and other diseases responsible for the high infant mortality in Latin American countries. High morbidity in childhood and adulthood certainly has a negative impact on one's economic productivity at home and in the labor market. When death takes place in childhood, before one produces goods and services sufficient for offsetting the past consumption of resources, the economic loss due to the death may be calculated in terms of consumption of resources, i.e., net national product. By calculating the economic loss represented by child mortality under the age of 15, Kuznets (1980) intends to answer the following questions: "What unoffset consumption inputs might have been avoided if the children and yound adults whose deaths we are considering had never been born?"[6]

For illustration of economic loss, we use the following demographic data for Costa Rica in Tables 1 and 2:

Table 1

Costa Rica

Total Population (P_T) in 1976: 2,012,000*

Population by Age Group in 1975 (%)**

0 - 14	15 - 64	65 and over
42.2	54.5	3.3

Note. Population by age group in 1976 is not found. Therefore, the figures in 1975 are used as an approximation for the calculation of economic loss in 1976.

Source: * Demographic Yearbook 1979, 31st Edition, p.108.
** Statistical Abstract of Latin America, Vol.21, Table 104 Demographic Indicator, 20LR, 1960-80, p.6.

Table 2

Costa Rica

Deaths by Age and Sex in 1976

	0 - 1	1 - 4	5 - 9	10 - 14
Male	1,106	217	83	76
Female	882	169	70	48
Total	1,988	386	153	124

Source: Demographic Yearbook 1977, 29th Edition, General Mortality: 19. Deaths by Age and Sex, p.376

Kuznets (1980) assumes that total income (or net products of the nation) is the sum of all consumption: Consumption per child under the age of 15 is 0.5 of that (=1.0) per adult of working ages 15 - 64 and consumption per adult aged 65 and over is 0.75 of that per adult of working ages 15 - 64. Then, economic loss is defined as follows:

$$\text{Economic Loss} = \frac{0.5 \sum_{i=1}^{k} X_i P_i ASDR_i}{0.5\ P_{0-14} + 1.0\ P_{15-64} + 0.75\ P_{65 \text{ and over}}},$$

which is equivalent to

$$\text{Economic Loss} = \frac{0.5 \sum_{i=1}^{k} X_i \, CDR_i}{0.5\,P_{0-14} + 1.0\,P_{15-64} + 0.75\,P_{65 \text{ and over}}},$$

where X_i is the midpoint of age class i, i = 0 - 1, 1 - 4, 5 - 9, and 10 - 14; P_i is population share of age class i; $ASDR_i$ is age-specific death rate per 1,000 of age class i; and CDR_i is crude death rate of age class i per 1,000 population.

By using the demographic data for Costa Rica in Tables 1 and 2, we obtain the economic loss in 1976 as follows:

Table 3

Economic Loss in Costa Rica in 1976

Ages	X_i	(A) $0.5X_i$	(B) CDR_i	(A)x(B)
under 1	0.50	0.25	$(1{,}988/P_T) \times 1{,}000 = 0.9880$	0.2470
1 - 4	3.00	1.50	$(386/P_T) \times 1{,}000 = 0.1918$	0.2877
5 - 9	7.50	3.75	$(153/P_T) \times 1{,}000 = 0.0760$	0.2850
10 - 14	12.50	6.25	$(124/P_T) \times 1{,}000 = 0.0616$	0.3850
			Total	1.2047

Economic Loss = (1.2047/(0.50x42.2+1.00x54.5+0.75x3.3))x100

= 1.543% of the net products of the nation

Note. P_T = 2,012,000. Age group i - j means i - under j+1, e.g., 1 - 4 = 1 - under 5.

The last column in Table 10 shows the economic loss of child mortality under the age of 15 for the nineteen Latin American countries for the specified years. Surprisingly enough, there is significant variation for the economic loss across the countries -- from 0.99%(Uruguay) to 18.93% (Haiti) of net national products. Some economic losses are substantially larger in recent years than those values found by Kuznets (1980) for Egypt (2.68%) and the Netherlands (0.17%) in 1937. In the case of Haiti (18.93%), we notice that the distribution of doctors between the cities with over 100,000 and the country as a whole is the most unequal among the Latin American countries (see the last column of Table 12), and the fractions of urban population in 1960 and 1980 are much smaller than in any other countries in Latin America (see Table 13: P1960 and P1980). Since the fraction of infant mortality in total deaths is relatively small in Haiti (see Table 10: INFD/TD = 5% in 1972), the large economic loss in Haiti is mainly due to the child mortality between ages 1 and 14. Therefore, for Haiti and other Latin American countries as well the reduction in high morbidity and mortality rates in childhood and young adulthood will benefit various economic and social groups and consequently lead to their economic development.

In summary, this section presents recent cross-sectional data for major causes of death and for some medical aspects in Latin

America. Three groups of diseases -- influenza and pneumonia, enteritis and other diarrheal diseases, and other infective and parasitic diseases -- are in strikingly larger proportion in the total death rate than those same groups in the United States. For example, those three groups of diseases account for one-third or more of total deaths for many Latin American countries, while they account for only about 4% of the total deaths in the United States in 1975. Also, we note that medical doctors are heavily distributed in cities with over 100,000 population, relative to rural areas. The average number of inhabitants per doctor in the cities is 861 in the period of 1968-1971, while the average overall of country is 2,877 in the same period. Finally, the economic loss due to child mortality under the age of 15 in Latin American countries is calculated on the basis of the Kuznets method (1980) and points out a significant variation from 0.99% of the net national product in Uruguay to 18.93% in Haiti. Surprisingly enough, eleven of the nineteen Latin American countries show their economic losses to be more than 3% of their net national products in recent years, in contrast to those values found by Kuznets (1980) for Egypt (2.68%) and the Netherlands (0.17%) in 1937.

II. STATISTICAL TECHNIQUES OF A DYNAMIC MODEL

Granger (1969) defines causality between two stationary stochastic time series, X(t) and Y(t), within a set of information in the universe as follows: A time series X causes another time series Y if the current value of Y is more accurately predicted by using the information which includes at least the own-past series of Y and the past series of X, than by using the information which excludes the past series of X. [7]

By using a logarithmic specification, the following linear model is estimated:

$$\widehat{X}_i(t) = \widehat{a}_0 + \sum_{i=1}^{q} \sum_{s=1}^{n} \widehat{a}_i(s)\, X_i(t-s) + \widehat{b}\, T, \quad \ldots\ldots(1)$$

where $\widehat{a}_0$, $\widehat{a}_i$, and $\widehat{b}$ are the least-square estimates; X_i represents infant mortality rate, birth rate, and real per capita income for $q = 3$; and T is a linear time trend. In order to identify the Granger-causality from X_j to X_i, $j \neq i$, in equation (1), the null hypothesis is that the set of parameters $a_j(s)$, $s = 1, \ldots, n$, should be zero if there is no Granger-causality from X_j to X_i.

With respect to dynamic relationships between X_i and X_j, $i \neq j$, the estimated coefficients on successive lags include complicated cross-equation feedbacks and, therefore, summing the distributed lagged coefficients, e.g., $a_j(s)$, is quite misleading (Sims 1980). Therefore, the moving average representation is an alternative method to observe the effects of X_j on X_i.[8]

Let $\hat{X}(t)$ represent the best linear forecast of X(t) based on its past series X(t-s), s > 0, where X(t) is an q x 1 vector stationary stochastic time series. Then, the innovation in X(t), U(t), is defined as

$$U(t) = X(t) - \hat{X}(t), \qquad \ldots\ldots (2)$$

where U(t) is serially uncorrelated and is also a linear combination of current and past values of X(t) for all t. Then, X(t) can be expressed as a linear combination of innovation U(t-s), s ≥ 0. However, if components of U are contemporaneously correlated, it is not possible to partition the variance of X into pieces accounted for by each innovation. Therefore, an orthogonalizing transformation to U is required to obtain E(t) = TU(t), where T is a lower triangular matrix with zero elements above the diagonal elements, which makes the covariance matrix of E(t) the identity matrix. The final equation to estimate is as follows:

$$X(t) = \sum_{s=0}^{\infty} G(s)\, T^{-1} E(t-s) \; . \qquad \ldots\ldots (3)$$

Given the above equation (3), a particular i-th estimated equation of X(t) is expressed as follows:

$$X_i(t) = \sum_{j=1}^{q} \sum_{s=0}^{k} g_{ij}(s)\, e_{ij}(t-s) \;, \quad \ldots\ldots (4)$$

where e's are the innovation in infant mortality rate, the innovation in birth rate, and the innovation in real per capita income since q = 3; and $g_{ij}(s)$ represents the estimated coefficients of the k+1 step-ahead forecast X_i, whose coefficients are accounted for by the innovation in X_j. Consequently, the proportion of k years ahead forecast error variance in X_i due to typical random shocks of one standard deviation in the innovation in X_j is given as follows[9]:

$$\rho^2_{ij}(k) = \frac{\sum_{s=0}^{k} g^2_{ij}(s)}{\sum_{j=1}^{q} \sum_{s=0}^{k} g^2_{ij}(s)} \;. \quad \ldots\ldots (5)$$

III. EMPIRICAL RESULTS

III-1. Granger-Causality Tests

Granger-causality tests among infant mortality rate, birth rate, and real per capita income are performed using the annual time-series data for the eleven Latin American countries.[10] Real per capita income is used as a proxy variable for economic development in each country, which is, in fact, the best single economic variable representing the level of standards of living in the country (Preston 1975). Birth rate is also included in the system because the rates are typically high in Latin American countries. The logarithmic results of four lag distributions are reported in Tables 4 and 5.

Table 4 contains the F-statistics on the four lag coefficients of the explanatory variables, infant mortality rate (INF), birth rate (BIR), and real per capita income (INC), when infant mortality rate is the dependent variable and other two are the causal variables. On the other hand, Table 5 lists the F-statistics when birth rate is the dependent variable and other two are the causal variables.

Concerning the issue of Granger-causality from real per capita income (INC) to infant mortality rate (INF) in Table 4, there are only two countries, Costa Rica and Mexico, that show the Granger-causality from economic development to infant mortality.

Of the two countries, Costa Rica has a result that is marginally significant at the 10% significance level. Therefore, these overall results do not reject the demographer's viewpoint that the economic developments in Latin American countries have been a minor contributing factor in reducing the infant mortality rates in recent decades.

Similarly, a Malthusian argument is not found in many Latin American countries: A higher birth rate results in a higher infant mortality rate. Birth rate (BIR) Granger-causes infant mortality rate (INF) only for these three countries: Honduras, Mexico, and Chile, of which the results of Mexico and Chile indicate relatively large F-statistics, 7.366 and 6.241, respectively. Therefore, reducing their birth rates probably can help to lower the infant mortality rates in these countries.

With respect to the issue of Granger-causality from real per capita income (INF) or infant mortality rate (INF) to birth rate (BIR) in Table 5, the economic development Granger-causes the birth rates in Honduras, Chile, Ecuador, and Uruguay. In terms of the number of statistically significant countries, the economic developments seem to have reduced the birth rates rather than the infant mortality rates.

In the theory of demographic transition, mortality rates decline prior to a fall in birth rate. However, the response in birth rate to the decline in infant mortality rate does not strongly support the idea of demographic transition in Latin America. That is, the birth rates in Latin America have not been very responsive to the fall in the infant mortality rates in recent decades. On the other hand, the birth rates are fairly well explained by their own past behaviors for many countries such as Costa Rica, Honduras, Mexico, Chile, and Uruguay.

As a summary of Granger-causality tests for the causes of the fall in the infant mortality rates in Latin America, the empirical results seem to support the view that medical and health technological development is the major cause of the reduction in infant mortality rates in recent decades. In some Latin American countries, a fall in birth rate probably lowers infant mortality rate, while the former is strongly influenced by its own past behavior and economic development.

TABLE 4

Granger-Causality Test

Dependent Variable: Infant Mortality Rate

F-Statistics on Explanatory Variables

Country	(d.f.)	INC	BIR	INF	Time Period
Central America					
Costa Rica	(4,14)	2.400*	1.691	1.805	1952-1979
Dominican Republic	(4,11)	1.153	1.360	7.085***	1952-1976
El Salvador	(4,13)	0.097	0.409	0.265	1952-1978
Guatemala	(4,14)	0.791	1.622	0.824	1952-1979
Honduras	(4,11)	2.531	3.909**	3.218*	1952-1976
Mexico	(4,13)	8.571***	7.366***	2.332	1952-1978
South America					
Chile	(4,13)	1.490	6.241***	1.033	1952-1978
Colombia	(4,12)	0.889	0.601	1.525	1952-1977
Ecuador	(4,13)	1.853	2.135	1.237	1952-1978
Uruguay	(4,12)	1.218	1.282	1.076	1952-1977
Venezuela	(4,14)	1.788	1.739	2.570*	1952-1979

Note. The issue of Granger-causality is from real per capita income (INC) or birth rate (BIR) to infant mortality rate (INF). (d.f.) is degrees of freedom.

* Significant at α = 10%

** Significant at α = 5%

*** Significant at α = 1%

TABLE 5

Granger-Causality Test

Dependent Variable: Birth Rate

F-Statistics on Explanatory Variables

Country	(d.f.)	INC	INF	BIR	Time Period
<u>Central America</u>					
Costa Rica	(4,14)	1.446	1.842	6.256***	1952-1979
Dominican Republic	(4,11)	1.036	1.801	0.955	1952-1976
El Salvador	(4,13)	0.521	0.865	0.851	1952-1978
Guatemala	(4,14)	0.539	0.953	0.667	1952-1979
Honduras	(4,11)	6.141***	4.442**	8.089***	1952-1976
Mexico	(4,13)	0.581	1.649	6.055***	1952-1978
<u>South America</u>					
Chile	(4,13)	2.579*	4.116**	14.18***	1952-1978
Colombia	(4,12)	0.977	0.319	0.251	1952-1977
Ecuador	(4,13)	5.404***	0.144	0.977	1952-1978
Uruguay	(4,12)	3.377**	1.097	2.956*	1952-1977
Venezuela	(4,14)	0.793	0.913	1.678	1952-1979

Note. The issue of Granger-causality is from real per capita income (INC) or infant mortality rate (INF) to birth rate (BIR). (d.f.) is degrees of freedom.

* Significant at $a = 10\%$

** Significant at $a = 5\%$

*** Significant at $a = 1\%$

III-2. Dynamic Responses of Infant Mortality Rate

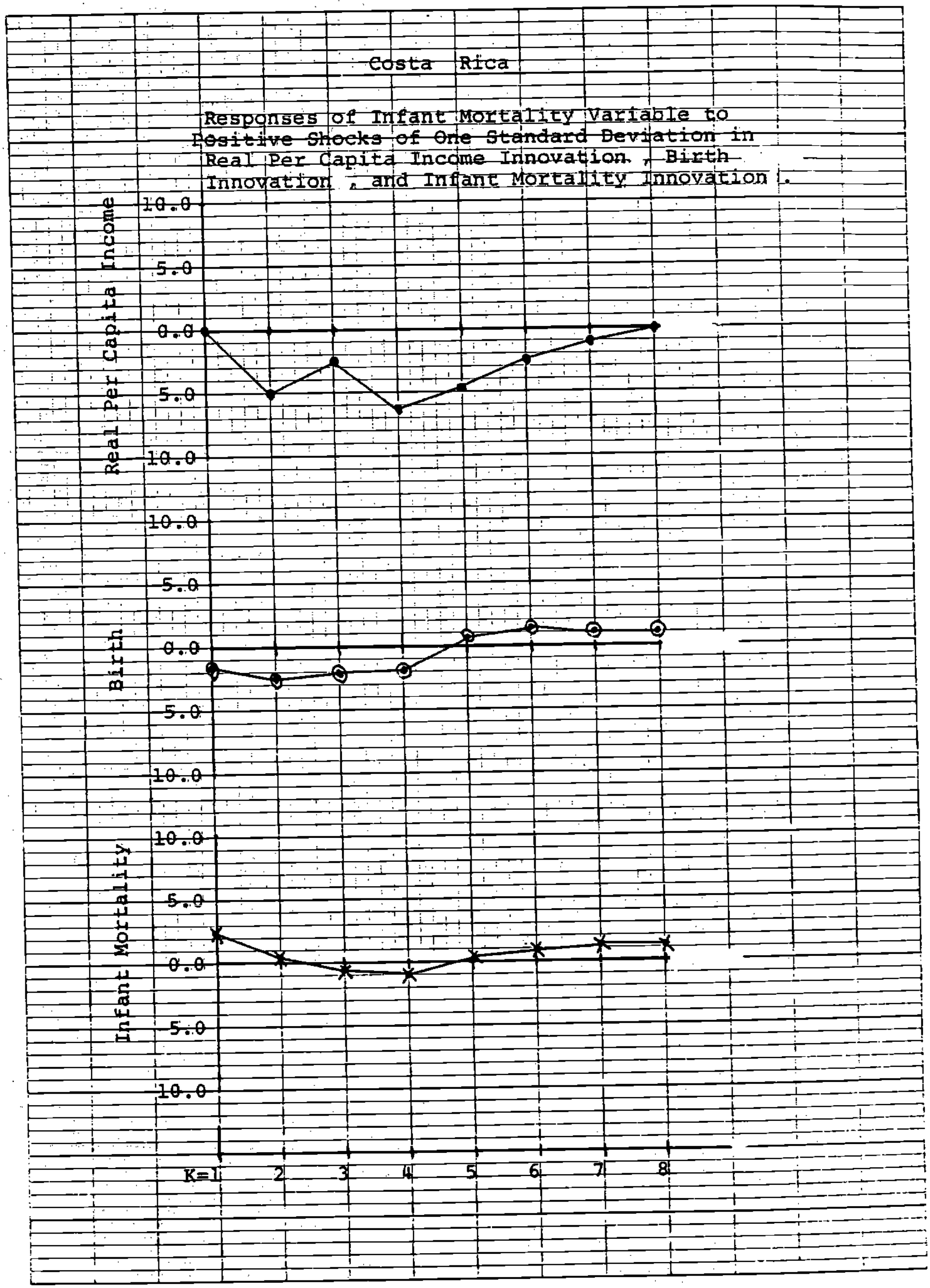
In the previous section, it was argued that real per capita income as a proxy variable for economic development has little power to explain the infant mortality behavior in Latin America. Only the results of Costa Rica and Mexico indicate Granger-causality from economic development to infant mortality rate, although the former is marginally significant at the 10% significance level. In this section, rather than depicting the dynamic relationships among real per capita income, infant mortality rate, and birth rate for the eleven Latin American countries, I present the dynamic responses of infant mortality rate to real per capita income and birth rate of Costa Rica and Mexico in the forms of charts (Tables 6 and 7) and decomposition of variance of infant mortality rate (Tables 8 and 9).

First, concerning the case of Costa Rica, Table 6 shows the responses of infant mortality rate to real per capita income innovation, birth innovation, and infant mortality innovation; Table 8 indicates the corresponding variance decomposition of infant mortality explained by each innovation. As we can see in the top chart of real per capita income innovation in Table 6, positive random shocks of one standard deviation in the innovation tend persistently to decrease the infant mortality at the time horizons shown, and the dynamic effects seem to complete in the eighth year. On the other hand, the birth innovation tends to decrease temporarily the infant mortality below trend level and increase eventually above trend level, although the importance is negligible on the basis of the Granger-causality test. Table 8 provides the decomposition of variance of infant mortality. The infant mortality initially has 60% of its variance accounted for by its own innovation, while the rest is explained by the birth innovation at k = 1. The proportion explained by its own innovation diminishes as more future is forecast, e.g., only 8% of the variance of infant mortality being explained by its own innovation at k = 8. However, the income innovation explains 75% of the variance of infant mortality at k = 8. Therefore, over long horizons the economic development (the real per capita income) is the main source of variation in infant mortality in Costa Rica.

Second, with respect to the result of Mexico in Table 7, the income innovation shown in the top chart generates a large fluctuation in the infant mortality and the former decreases the latter below trend level over long horizons. It is a little puzzling why the infant mortality increases above trend level at k = 3 through k = 6 after initial random shocks in the income innovation. In the middle chart, the birth innovation is followed by an apparent increase in the infant mortality at k = 5 and after. According to the decomposition of variance of infant mortality shown in Table 9, the infant mortality has 77% of its variance at k = 1 but has only 8% at k = 8 accounted for by its own innovation, indicating that the dynamic effects from the other two variables are significantly strong. Over the long horizons shown, the main source of variation in infant mortality comes from the fluctuations in real per capita income and birth innovations.

As a summary for this section, when economic development Granger-causes infant mortality, the former becomes the main source of variation in the latter over long horizons. Also, an increase in birth seems to have a corresponding increase in infant mortality with a lag over long horizons.

TABLE 6


Costa Rica
Responses of Infant Mortality Variable to Positive Shocks of One Standard Deviation in Real Per Capita Income Innovation , Birth Innovation , and Infant Mortality Innovation .
Real Per Capita Income
10.0
5.0
0.0
5.0
10.0
Birth
10.0
5.0
0.0
5.0
10.0
Infant Mortality
10.0
5.0
0.0
5.0
10.0
K=1
2
3
4
5
6
7
8

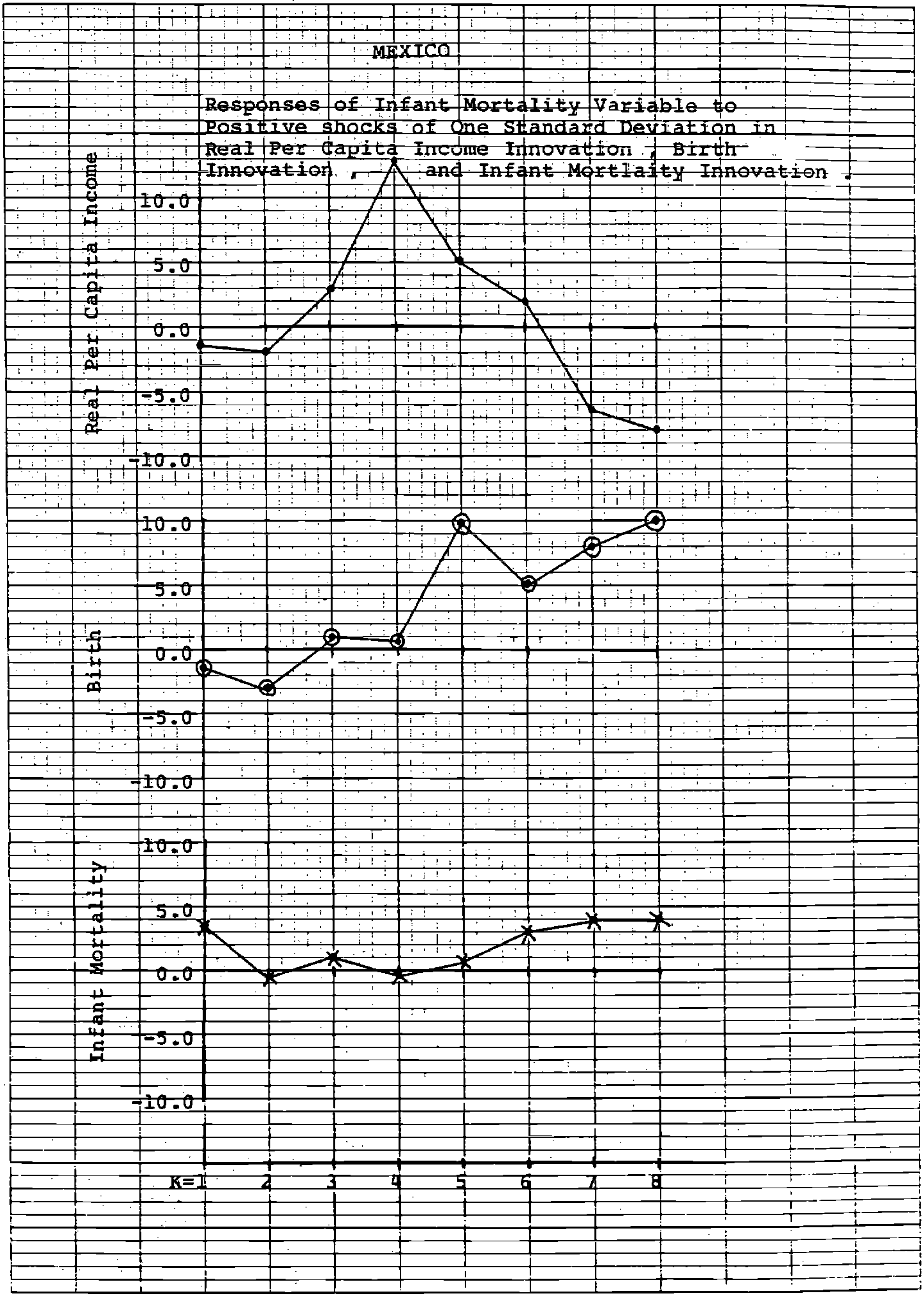

MEXICO
Responses of Infant Mortality Variable to Positive shocks of One Standard Deviation in Real Per Capita Income Innovation , Birth Innovation , and Infant Mortlaity Innovation .
Real Per Capita Income
Birth
Infant Mortality
10.0
5.0
0.0
-5.0
-10.0
K=1
2
3
4
5
6
7
8

TABLE 8

Costa Rica

Decomposition of Variance of Infant Mortality:
Percentages of Forecast Error Variance 1, 3,
5, and 8 Years Ahead Produced by Each Innovation

Response in	K	Innovation in Real Per Capita Income	Innovation in Birth	Innovation in Infant Mortality
Infant Mortality	1	0.00	0.40	0.60
	3	0.61	0.28	0.11
	5	0.79	0.15	0.06
	8	0.75	0.17	0.08

TABLE 9

Mexico

Decomposition of Variance of Infant Mortality:
Percentages of Forecast Error Variance 1, 3,
5, and 8 Years Ahead Produced by Each Innovation

Response in	K	Innovation in Real Per Capita Income	Innovation in Birth	Innovation in Infant Mortality
Infant Mortality	1	0.10	0.13	0.77
	3	0.40	0.25	0.45
	5	0.63	0.33	0.04
	8	0.47	0.45	0.08

IV. SUMMARY

Despite the unprecedented fall in infant mortality rate in Latin America in recent decades, the infant mortality rate is still substantially higher than the rate in Western countries. The aim of this study is twofold: One is to calculate economic loss in terms of net national product due to child mortality under the age of 15, and another is to answer empirically the question of whether the decline of infant mortality has been principally a product of economic development in Latin America in recent decades.

With respect to the economic loss represented by child mortality under the age of 15, there is significant variation from 0.99 to 18.93% of net national products across Latin American countries, of which eleven show their economic losses to be more than 3% of the net national product. The high mortality in childhood, reflecting the high economic losses, seems to result largely from the following diseases: influenza and pneumonia, enteritis and other diarrheal diseases, and other infective and parasitic diseases. In explaining the high morbidity and child mortality rates, we note that there exist significant differentials in medical services, distribution of population, and literacy rate between urban and rural areas in Latin America.

The Granger-Sims dynamic system shows that economic development in Latin America does not have strong explanatory power in accounting for the behavior of infant mortality rate in recent decades. Therefore, the empirical results seem to support the view that medical and health technological development is the major cause of the reduction in infant mortality rates in Latin American countries in recent decades. However, when economic development Granger-causes infant mortality as observed for only two countries, the former becomes the main source of variation of the latter over long horizons.

FOOTNOTES

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[1] Arriaga and Davis (1969), p.226.

[2] Preston (1980), p.290.

[3] The source is Statistical Abstract of Latin America, Vol.21, Table 6 Social Indicators, 20L, 1960-79, p.7, which does not specify whether doctor means physician or not. However, the comparable data are listed in the same source in Table 800 Population per Physician, 20L, 1960-77, p.116. Therefore, I assume "doctor" equivalent to "physician."

[4] The average number of inhabitants per physician of overall country in Latin America in 1975 is about 1606, which, however, does not include the statistics of the following countries: Bolivia, Brazil, Chile, Dominican Republic, Guatemala, Haiti, Mexico, and Peru. Since these countries show relatively large numbers of inhabitants per physician in 1969 or 1970, the above overall average, 1606, in 1975 may not be directly comparable to the figure 2,877 in 1968-1971 in the text. The source is Statistical Abstract of Latin America, pp.7 and 116.

[5] Table 13 lists proportion of urban population and annual growth rate of urban population for two different periods. Urban is defined as areas with over 20,000 inhabitants. Since a national growth rate of population (see Table 10) is a weighted average of urban and rural growth rates of population, the growth rate of urban population seems at least twice as high as that of rural population. This seems to result from heavy migration from rural to urban areas (Cabello 1966) and lower mortality rates in urban areas. Another datum listed in Table 13 -- the literacy differential between urban and rural people -- indicates the significant differentials between urban and rural females for Mexico, Nicaragua, Brazil, Chile, and Peru. These differentials in population and literacy rate between urban and rural areas probably help to explain partially the differential in infant mortality risk between the two areas.

[6]Kuznets (1980), p.502.

[7]"Causality" in Granger's model means "linear causality between variables within a given set of information in a universe." See Granger (1969), p.430. Blinder (1982) states that "Granger-causation has nothing to do with causation in the usual sense ... It means that X adds to the ability to predict Y, no more and no less [pp.15-16]."

[8]The rest of this section draws heavily on Sims (1980) and Eckstein et al. (1981).

[9]A similar formula is found in Eckstein et al. (1981).

[10]The infant mortality rate and the birth rate are obtained from Demographic Yearbook, Special Issue 1979, and Population and Vital Statistics Report, Statistical Papers Series A: Vol.32, no.4 (1980), Vol.33, no.1, no.2, no.3 (1981), and Vol.34, no.2 (1982). The source of real per capita income is Statistical Abstract of Latin America, Vol21, Table 2201 Per Capita GDP in Constant Dollars of 1970, 19LR, 1940-79, pp.276-277. Because of the limitation of these above data, the following countries are possible to be examined by Granger-causality tests: Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Mexico, Chile, Colombia, Ecuador, Uruguay, and Venezuela. For obvious reasons of scarce and incomplete data of Latin American countries, and answer to the question by Granger-causality tests should be speculative.

APPENDIX

TABLE 10

Demographic Statistics and Economic Losses

Country	$\dot{P}/P$(%) 1960-'70	$\dot{P}/P$(%) 1970-'79	1975 P_{0-14}(%)	INF_{1950}	INF_{1975}	1975 $\frac{INFD}{TD}$ (%)	Economic (%) Losses (1975)
Central America							
Costa Rica	3.4	2.5	42.2	90.34	36.26	23	1.54*('76)
Cuba	2.0	1.4	38.0	n.a.	26.58	11	1.24*('71)
Dominican Republic	2.9	2.9	48.0	84.74	42.50	28	3.17
El Salvador	2.9	2.9	46.5	87.44	57.02	29	3.84*('76)
Guatemala	2.8	2.9	44.2	106.02	78.38	26	10.04*('77)
Haiti	1.5	1.7	42.9	n.a.	n.a.	5#('72)	18.93**('72)
Honduras	3.1	3.3	46.9	78.20	33.06	23	4.61*('76)
Mexico	3.2	2.9	45.9	98.58	51.54	27	3.54
Nicaragua	2.9	3.3	48.4	n.a.	n.a.	30#('65)	4.51**('65)
Panama	2.9	2.3	42.8	n.a.	n.a.	18#('77)	2.43
South America							
Argentina	1.4	1.6	28.5	67.40	58.90('70)	12#('78)	1.20*('78)
Bolivia	2.3	2.5	43.0	115.14	n.a.	24#('66)	6.36**('66)
Brazil	2.9	2.2	42.0	n.a.	n.a.	n.a.	n.a.
Chile	2.1	1.7	36.3	141.26	59.96	19	1.77*('76)
Colombia	3.0	2.3	45.7	124.94	47.80	22#	3.53
Ecuador	3.1	3.3	46.0	113.32	71.06	26	5.43
Paraguay	2.6	2.9	47.3	n.a.	n.a.	21#('77)	2.82*('76)
Peru	2.8	2.7	44.1	n.a.	n.a.	31#	3.93**('71)
Uruguay	1.1	0.3	27.9	56.58	48.26	9	0.99
Venezuela	3.4	3.3	44.4	85.68	45.88	26	2.67
United States	1.3	1.0		29.88	15.94	3##	

(continued)

Note. $\dot{P}/P$ is average annual growth of population. Source: the World Development Report 1981, Table 17 Population Growth, Past and Projected, and Hypothetical Stationary Population. pp.166-167.

P_{0-14} is the proportion of population aged 0 through 14 years. Source: Statistical Abstract of Latin America, Vol. 21, Table 104 Demographic Indicators, 20LR, 1960-80. p.6.

INF is a simple 5 year moving average. Source: Demographic Yearbook 1979 (Special Issue), 1 Estimates of Mid-Year Population and Vital Statistics Summary: 1948-1978. PP. 108-129. INF1975 for Dominican Republic, Honduras, and Colombia is a simple 3 year moving average because of deficiency of data.

INFD/TD is a ratio of the number of infant mortality to total mortality. Source: 1 Estimates of Mid-Year Population and Vital Statistics Summary: 1948-1978. PP.108-129. # Source: Demographic Yearbook 31st Edition 1979, General Mortality 19. Deaths by Age and Sex, pp.386-390. ## Source: Demographic Yearbook 29th Edition 1977, General Mortality 18. Deaths by Age and Sex, p.380.

Economic Losses are calculated based on the method of Kuznets (1980), pp.499-501. Proportions by age 0-14, 15-64, and 65 and over are obtained from Statistical Abstract of Latin America, Vol 21, Table 104 Demographic Indicators, 20LR, 1960-80, p.6. Deaths by age under 1, 1-4, 5-9, and 10-14 are obtained from Demographic Yearbook 29th Edition 1977, 19. Deaths by Age and Sex, pp.376-383 and Demographic Yearbook 31st Edition 1979, 19. Deaths by Age and Sex, pp. 384-391.

* Proportions by age 0-1,..., 65 and over use those in 1975 as a denominator for calculation, but deaths by age under 1,..., 10-14 use those specified years in parentheses. ‡ Proportions by age use those in 1970, but deaths by age use those specified years in parentheses. Total population in each country (P_T) is mostly obtained form Demographic Yearbook 1979, 31st Edition, pp.108-129.

TABLE 11

Major Diseases as Causes of Death
(all causes = 100)

	Disease of Hearts	Malignant Neoplasms	Cerebrovascular Disease	Influenza & Pneumonia	Enteritis & other Diarrheal Disease	Other Infective & Parasitic Disease
Central America						
Costa Rica (1975)	14.0%	14.1%	5.5%	6.3%	('74) 5.4%	5.6%
Cuba (1975)	27.2	18.2	9.3	7.1	('73) 1.7	3.0
Dominican R. (1975)	8.4	3.9	3.2	--	8.4	('74) 6.3
El Salvador (1974)	3.3	--	--	4.1	13.3	('73) 6.7
Guatemala (1975)	--	2.2	--	15.7	18.3	('71) 20.5
Haiti	--	--	--	--	--	--
Honduras (1975)	9.0	2.5	--	4.3	14.2	('73) 10.0
Mexico (1974)	9.9	4.8	--	13.1	11.7	('73) 7.2
Nicaragua (1973)	6.6	--	4.0	3.3	18.7	8.4
Panama (1974)	12.3	7.8	6.8	7.3	5.5	8.5
South America						
Argentina (1970)	24.4	16.2	9.0	4.4	2.5	4.4
Bolivia	--	--	--	--	--	--
Brazil	--	--	--	--	--	--
Chile (1975)	11.2	14.1	7.7	9.7	('74) 3.7	5.3
Colombia (1975)	16.0	8.1	5.7	7.2	7.7	('73) 8.2
Ecuador (1974)	6.9	--	--	9.5	11.9	('72) 13.2
Paraguay (1975)	11.5	7.0	6.9	7.6	9.1	('74) 7.0
Peru (1972)	5.2	5.6	--	20.5	11.6	12.1
Uruguay (1976)	23.9	20.1	12.3	3.1	('74) 1.1	2.6
Venezuela (1975)	13.2	8.7	--	6.7	5.7	('74) 6.0
United States (1975)	38.2	19.3	10.3	2.9	('74) 0.1	0.7

Source: Statistical Abstract of Latin America, Vol.21, table 707 in p.106 and table 712 in pp. 110-112.

Note. Enteritis & other diarrheal disease and other infective & parasitic disease listed after the specified years in parenthses represent those of the years, e.g., 5.4% and 5.6% in Costa Rica indicate enteritis & other diarrheal disease and other infective & parasitic disease in 1974, respectively.

TABLE 12

Hospital Beds and Physicians

Country	Hospital Beds/ 1,000pop	Inhab/Doc 1968-'71	Inhab/Doc in Cities 1968-'71	Distribution of Doctors
Central America				
Costa Rica	3.5 ('77)	1,804	860	2.1
Cuba	4.0 ('78)	1,123	n.a.	
Dominican Republic..	2.8 ('73)	2,247	1,123	2.0
El Salvador	1.8 ('78)	5,101	1,379	3.7
Guatemala	2.0 ('73)	4,498	776	5.8
Haiti	0.8 ('76)	15,750	1,382	11.4
Honduras	1.3 ('78)	4,085	950	4.3
Mexico	1.2 ('74)	1,726	691	2.5
Nicaragua	2.2 ('76)	2,014	650	3.1
Panama	3.9 ('77)	1,616	735	2.2
South America				
Argentina	5.4 ('73)	521	401	1.3
Bolivia	1.8 ('75)	2,174	702	3.1
Brazil	3.8 ('73)	1,918	800	2.4
Chile	3.6 ('78)	1,803	1,202	1.5
Colombia	1.7 ('78)	2,341	1,065	2.2
Ecuador	2.1 ('73)	2,928	1,046	2.8
Paraguay	1.5 ('76)	1,811	504	3.6
Peru	2.0 ('73)	1,917	600	3.2
Uruguay	5.7 ('71)	1,032	688	1.5
Venezuela	3.4 ('77)	1,115	797	1.4
United States	6.3 ('77)			