NÚMERO 180

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THE LONG-TERM IMPACT OF HEALTH ON ECONOMIC GROWTH IN LATIN AMERICA

Resumen

Utilizamos regresiones de crecimiento adaptadas como pruebas de causalidad de tipo Granger para obtener evidencia fuerte de que una fuerte causalidad de la salud al ingreso, para una base de datos de dieciocho países Latinoamericanos que con un horizonte de 30 años. El indicador de salud es la probabilidad de sobrevivencia por grupos de edad y género para los años 1950-1990. Los incrementos quinquenales típicos de este período en la salud de los adultos y, sorprendentemente, de los viejos, se encuentran asociados con un incremento permanente de entre 0.8% y 1.5% anual en el ingreso. Los canales de causalidad de la salud al ingreso son diversos y deben ser identificados en estudios microeconómicos, que, sin embargo, deben incluir una amplia gama de fenómenos de largo plazo para comprender plenamente los efectos económicos de la salud.

Abstract

Growth regressions adapted as Granger-type causality tests give strong evidence of thirty-year conditional causality from health to income in eighteen Latin American countries. The health indicator is probability of survival by age and gender groups for 1950-1990. A permanent increment of between 0.8% and 1.5% annual income is associated with typical adult and, surprisingly, old age health improvements. The channels of causation from health to income are diverse and need to be identified in microeconomic studies, which, however, must include a wide variety long-term phenomena to fully account for the economic effects of health.

Introduction

How long is the horizon of health on economic growth and human development, and which are the age and gender groups having the largest effects? This is an important policy issue presently under discussion at, for example, the Pan American and World Health Organizations (1999a), which may result in a reevaluation of the priorities guiding resource allocation for health. Health improvement is both an outcome of, and a prerequisite for, development. The linkage from health to economic development and growth is complex and involves the accumulation resulting from a healthier workforce, the improved capability of families and individuals to work themselves out of poverty, and the complementarity between health and other investments such as education and capital. The key role of economic development in promoting health has been widely studied (World Bank, 1993, Pritchett and Summers, 1996). It is based on increased investment in health services, public health, and poverty programs, as well as on the improvements that come with increases in family wealth and hence investments in education and nutrition. However, the opposite relation, from health to economic growth, appears in the research agenda only very recently. In a Nobel prize winning series of works, Fogel (1991, 1992, 1994[a], 1994[b]), who states that about a third of the economic growth in England over the last 200 years is due to improvements in nutrition and health. More recent works study a whole series of ways in which health and economics interact. Amongst these are a series of micro-economic studies of health as an investment in human capital. These studies apply an integrated model of returns to human capital. They include education, nutrition, health, and migration to identify the independent impact of each on wages. As part of the identification strategy the models consider the inputs and policies that most effectively lead to the accumulation of each factor (Schultz, 1992, 1997; Thomas and Strauss, 1997; Strauss and Thomas, 1998, amongst many others). From the point of view of the theory of economic growth, in which health is considered as human capital, the role of health has been studied empirically by Barro (1996), who finds that life expectancy has a significant positive coefficient in growth regressions. Knowles and Owen (1995, 1997) include health capital in Mankiw, Romer and Weil's (1992) augmented Solow economic growth model, obtaining more significant results than education. Jamison and Wang (1998) find that survival rates contribute to growth more than education but less than decreases in fertility. Gallup and Sachs (1998) find that regions more prone to malaria grow less. Conducting a Levine-Renelt test

of the impact of health on economic growth in Latin America, Mora and Barona (1999) find that years lost to premature death is on occasion one of the few robust indicators of economic growth. Mayer (1999a) finds that health affects the dynamics of each of the main indicators of the socioeconomic transition in Brazil, namely income, education, fertility, female participation and wages.

In addition to its direct impact on productivity, health has other effects on both economic development and the demographic transition. Barro (1996), for example, theorizes that, by increasing longevity, health reduces the depreciation rate of human capital, making investments in education more attractive. In fact, good infant health and nutrition directly increase the benefits of education (World Bank, 1993; World Health Organization, 1999b). More generally, the burden of disease curtails the generation of income (ibid.). Ehrlich and Lui (1991) examine the impact of longevity on economic growth through intergenerational economic exchange. Theoretical considerations support the idea that health may affect the intertemporal discount rate and therefore saving (Mayer, 1999c). Health facilitates the economic participation of women in Brazil (Mayer, 1999a). This in itself is important for economic development (Galor and Weyl, 1993). Health also affects fertility, itself a pivotal phenomenon of the demographic transition, whose interactions with the economy have in turn been studied extensively. Finally, each of these mechanisms may have an impact on income distribution dynamics, which may itself affect growth (Birdsall and Londoño, 1997).

This article examines the causality (in the Granger sense, 1966) between health and income in the long-term, using a much longer data horizon than has been available in other studies on the impact of health on modern economic growth. Such a long-term macroeconomic study serves as a reference establishing the possible magnitude of the fully accumulated effects of health on income. It can be used to evaluate other results not including the full spectrum of health effects or a sufficiently long time for them to take place, which may therefore not fully account for the impact of health on income.

We work with quinquennial data base for 18 countries of Latin America including life tables for the period 1950-1990 and economic indicators for the period 1975-1990. The temporal extension of the health indicators permits a long-term analysis of the interaction between health and income per capita. We find that the impact of health on economic performance is a long-term phenomenon. In our results, the partial correlation of health indicators with future income becomes stronger as the time lag increases within the available 30 year data horizon. The availability of full life tables allow us to measure health as the *probability of survival* for each age and gender group. Although this concept is based only on mortality and does not include morbidity, it is much closer to what is meant by "health" than most indicators. The full set of survival probabilities contains much more information than life expectancy. We are able to investigate the role played by each age and gender group's health in promoting income. One of our findings is that old age health improvement contributes importantly to economic growth.

To analyze the Latin American data, we follow a method which is related to convergence studies (e.g. on the OECD countries, Dowrick and Nguyen, 1989, the U.S. states or the regions of Europe and Japan, Barro and Sala-i-Martin, 1991, 1992a, 1992b). Since our emphasis is not on convergence, the difficulties involved in establishing its existence and magnitude do not concern us. Instead we study the role of health as a determinant of future income and the role of income as a determinant of future improvements of male and female life expectancy. By using economic and lagged health indicators, these regressions conform a causality test similar to Granger's test, which detects evidence of long-term causality and permits an evaluation of its magnitude.

The rest of the paper is organized as follows. In section 2 we set out the study and its econometric strategy, including the causality test mentioned above. In section 3 we describe the results of the regressions and analyze their implications. In section 4 we make some final remarks.

The Study

The economic growth regressions we run are the following:

$$\frac{y_{s(t+5)} - y_{st}}{5} = \alpha y_{st} + \sum_i \beta_i X^i_{st} + \gamma_p PS_{s(t+5-5p)} + \sum_i c_i \chi_i + \varepsilon_{st}. \qquad (1)$$

Times t take the values 1975, 1980 and 1985. The variables are the following. y_{st} is the logarithm of income per capita. Variables X^i_{st} are the logarithms of: average number of years of primary schooling of the population over 25 years of age; real investment as a proportion of product; real "consumption" expenditure of the government as a proportion of product and total fertility (children per woman)[1]. These include indicators for the basic explanatory variables of economic growth, namely education, saving and population growth. PS_{st} are the probability of survival of different age and gender groups, which will be described below. Variables χ_i are temporal "dummies" for the years i running through 1975, 1980, 1985, which take into account temporal effects common to the countries in the sample, such as macroeconomic and technological shocks, etc.[2] Subindex s runs through the following 18 countries: Argentina, Bolivia, Brazil, Costa Rica, Chile, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, the Dominican Republic, Uruguay and Venezuela. During these years the average growth rates of these countries for the 5-year periods 1960-1965 to 1985-1990 were 2.2%, 2.4%, 3%, 2.1%, -2.2% and –0.6% respectively.

Equation (1) is equivalent to

[1] The five variables are GDPSH5, PYR, INVSH5, GOVSH5 and FERT from the well-known Barro Lee database (available on the World Wide Web).

[2] Without these dummies an error structure with different expected means for different periods would be introduced.

$$\frac{1}{5}y_{s(t+5)} = \alpha' y_{st} + \sum_i \beta_i X^i_{st} + \gamma_p PS_{s(t+5\ 5p)} + \sum_i c_i \chi_i + \varepsilon_{st}, \qquad (2)$$

where $\alpha' = \alpha + \frac{1}{5}$. Their results only differ in the t statistics of α and α', which are smaller for equation (1). Equation (2) constitutes a test of whether PS_{t+5-5p} Granger causes y_t, except for the presence of the additional explanatory variables. Thus it constitutes a *conditional* Granger causality test studying causality once the effects of the additional explanatory variables have been controlled. A significant coefficient γ_p indicates that the hypothesis that increments in the probability of survival of a given age and gender group cause increments in income per capita $5p$ years in the future cannot be rejected. The confidence interval for γ_p establishes a confidence interval for the magnitude of the proposed causal relation.

Results for 204 Economic Growth Regressions for 18 Latin American Countries (GLS, CSW, White)

Table 1
Coefficients and their Significance, Except for Health

	Coefficient			Probability		
	Minimum	**Average**	**Maximum**	**Minimum**	**Average**	**Maximum**
Initial Income	-9.17E-06	-7.26E-06	-1.82E-06	**6.20E-12**	**2.63E-03**	1.21E-01
Primary	-1.68E-02	-9.90E-03	-3.35E-03	**9.98E-18**	**1.22E-04**	**9.13E-03**
Investment	1.67E-02	1.27E-01	1.66E-01	**2.19E-11**	**1.30E-02**	5.22E-01
Government Consumption	-1.18E-02	1.96E-02	6.47E-02	**8.29E-02**	6.80E-01	9.98E-01
Fertility	-6.87E-03	-3.57E-03	3.10E-03	**3.40E-06**	3.30E-01	9.96E-01
Dummy75	-3.30E+00	-8.47E-01	8.65E-02	**8.93E-06**	**6.59E-02**	9.81E-01
Dummy80	-3.34E+00	-9.01E-01	4.22E-02	**1.18E-06**	**3.88E-02**	8.83E-01
Dumy85	-3.33E+00	-8.81E-01	6.17E-02	**2.98E-06**	**4.54E-02**	9.74E-01

(Bold types indicate a confidence level better than 1%)

Table 2
Global Statistics

	Minimum	Average	Maximum
R-squared	0.86	0.92	0.97
Adjusted R- squared	0.83	0.91	0.97
F statistic	32.19	71.15	179.25
Log probability	0.00000	0.00000	0.00000
Durbin-Watson	1.88	2.08	2.37
Number of observations	52	52	52

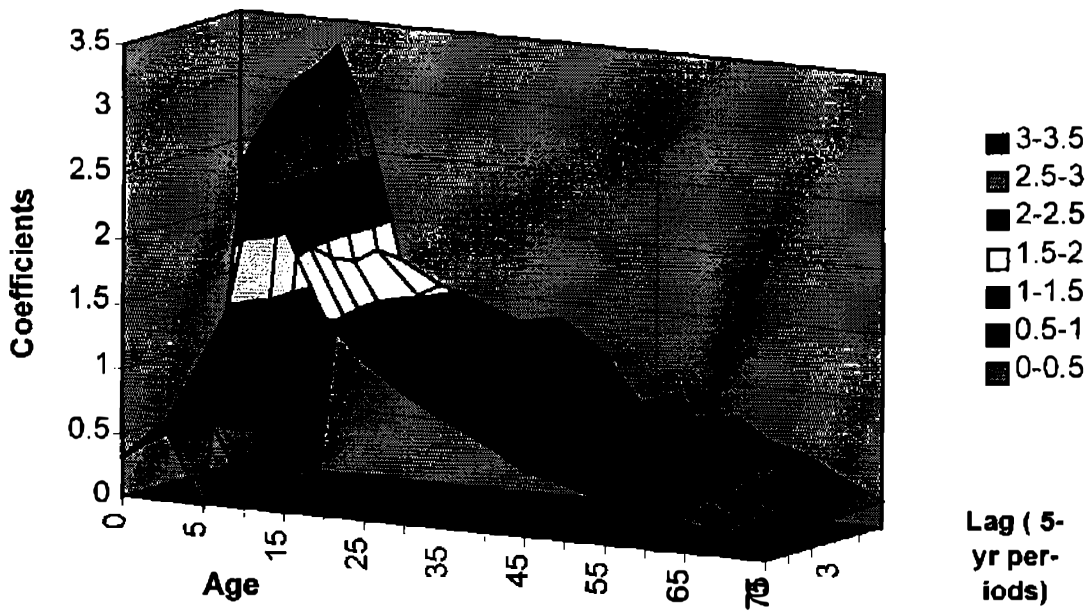
The probability of survival, a concept that in itself is an excellent health indicator, was defined to be consistent with the mathematical concept of life expectancy. For example, at time t, the probability PS_t of surviving 5 years satisfies the following equation:

$$LE_t = PS_t LE_{t+5} + (1 - PS_t)\frac{5}{2} \tag{3}$$

where LE_t is life expectancy at time t. If the subject does not survive, life expectancy of half the period is assumed. Excellent results were obtained with this indicator in a related study (Mayer, 1999a). The probabilities of survival which where calculated were the probability of surviving from 0 to 1 years of age, from 1 to 5, 5 to10, ..., and 75 to 80 years. The health variable was used with lags $5p$ of between 5 and 30 years.

Graph 1
Coefficients for the Lagged Probability of Survival (1% Significance) in 204 Economic Growth Regressions (18 Latin American Countries, GLS, CSW, White)

Women

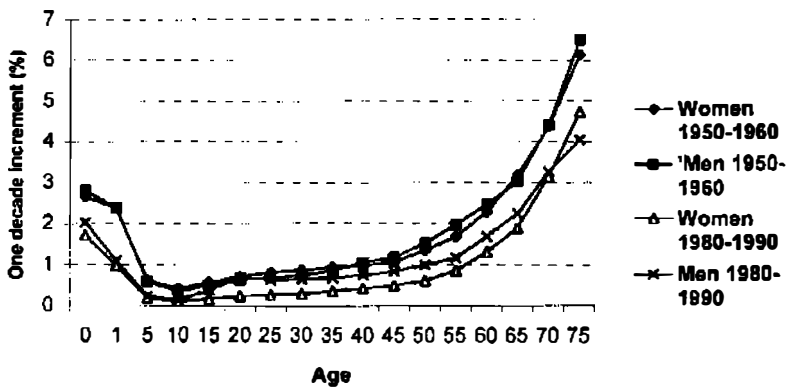


Thus overall the number of regressions estimated was 17 age groups × 2 genders × 6 lags = 204. Each of these regressions were estimated over a panel of 18 countries over 3 time periods (1975, 1980 and 1985).

Results

The regressions were estimated by generalized least squares, correcting for heteroskedasticity and correlation in the errors between countries. A statistical description of the coefficients obtained in the regressions for all of the variables, and their significance, except for health, is found in Table 1. The global statistics of the regressions are described in Table 2. It can be observed that initial income obtains a consistently negative sign (as expected by the hypothesis of conditional convergence) and is somewhat or very significant. "Average years of primary schooling for ages 25 and over" obtains a consistently significant negative sign (contrary to what is expected, as in Barro, 1991). Investment obtains a consistently positive sign (as expected from economic theory) which is somewhat or very significant. The coefficients of the remaining variables change sign. Additionally, the R squared, F and Durbin-Watson statistics are satisfactory for all of the regressions. Considering that each regression includes only 52 observations, the results are very good.

Graph 2
Percentage Increase in the Probability of Survival by Age and Gender Group for 1950-1960 and 1980-1990 (18 Latin American Countries)



The coefficients for the female health variables are shown in Graph 1, with non-significant coefficients (less than 1% confidence) set to zero. The male health indicators obtain similar but somewhat smaller and less significant coefficients, as holds almost generally in related studies carried out for Brazil and Mexico (Mayer, 1999a, 1999b). The shape of Graph 1 restricted to a 5-year lag is similar in shape and magnitude to the graph obtained by Mayer (1999a) for the Brazilian case. The highest coefficients are concentrated at the 10 year old age group, and diminish towards the younger and older age groups. What is important from the point of view of the long-term analysis that concerns us here is that the coefficients increase significantly towards the past for almost all of the age groups. The coefficients of

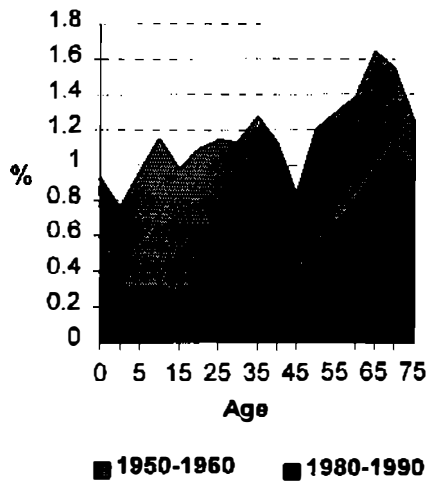
the adult age groups become larger, and in the case of the male indicators, more significant. Such an increase would not take place, for example, if the lagged variable were income per capita.

The long-term partial correlations observed here are confirmed by results obtained by Mayer (1999b) for Mexico. In that study the strongest links obtained for the effects of health on income occur for 25 year lags, also at the limit of the available data horizon. As in that study, adult health plays an important role.

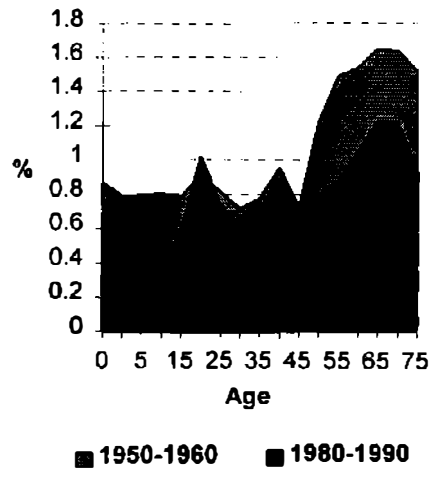
We will now analyze the magnitudes that these interactions between health and growth represent in real terms. To do this, we take into account the percentage increase in the probability of survival of men and women that actually occurred in the decades 1950-1960 and 1980-1990 and calculate the income growth with which these health improvements are associated by the regressions. Graph 2 shows that these health increments are lower for the later decade, especially for women.[3]

Contribution of Increments in the Probability of Survival Typical of the 1950-1960 and 1980-1990 Decades to Income 30 Years Later, by Age and Gender Group

Graph 3
Women



Graph 4
Men



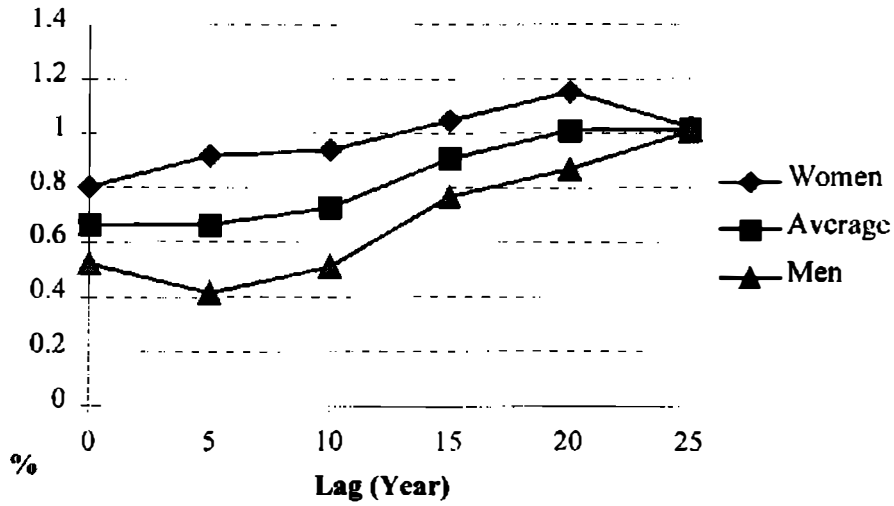
Graphs 3 and 4 show the economic growth associated with the health increments of the 50's and 80's. These are obtained by multiplying the coefficients of the regressions corresponding to the 30 year lag by the health increments to

[3] The information in our health data is insufficient to determine to what point the decreased improvements in health are due to decreasing returns to investment in health improvements in general or to the Latin American economic crisis of the eighties.

obtain the associated economic growth.[4] Since improvements in the probability of survival are relatively small between the ages of 5 and 15 (Graph 2), the shape of these graphs is different to the shape of the one for the coefficients (Graph 1). The contribution of the different age groups is much more uniform, and the contribution to growth associated with the health increments of the old stands out. Male and female young adults' health increments of the 50's are associated in the long term with income growth rates of between 0.8% and 1.1%. By comparison, the growth associated with the health increments of the older segment of the population is between 1.2% and 1.6%. The contribution that would be associated 30 years later with the health increments of the 80's is smaller. In this case men would contribute more than women, with the typical level descending to 0.6% or more for adults, and running at 0.3% for women. Only in the case of 20 year old men is the 1950-1960 level of contribution preserved. However, this seems to be due to a notable negative perturbation in the health of this sector of the population occurring in 1975 and 1980 (which extends to a lesser degree to 35 years of age).

Graph 5

Temporal Trajectory of the Impact of Health on Income



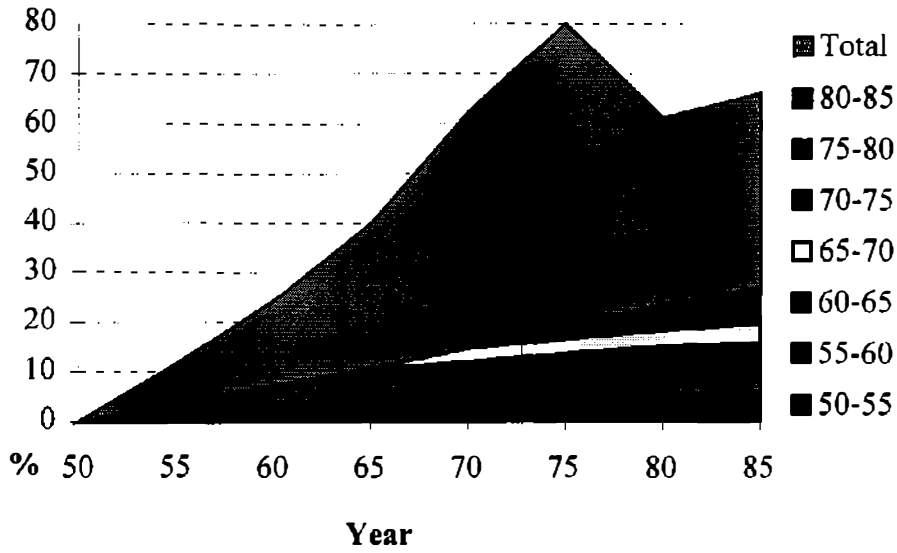
The comparison observed in Graphs 3 and 4 between the improvements in the level of income associated with the health increments of two different decades has important implications. The changes in the quantity and distribution of health

[4] We replaced the non-significant coefficients that occur for the 5 year old age groups and for the 55 year old female age group with the average of the neighboring coefficients.

improvements can considerably affect long-term economic growth. The impact of each age and gender group on economic growth is very sensitive to the health improvement experimented by each sector of the population. Even though the coefficients of female health indicators are larger and more significant, male health improvements may contribute more to growth.

Graph 6

Approximate Contribution to Income of 5-year Period Health Increments from 1950 to 1985 in Latin America



When we say that health increments lead to economic growth, we mean that through various channels they lead to income increments. Thus permanent increments in health lead eventually to permanent increments in income. These income increments take time to come into effect. The trajectory of the impact of health increments on income over time is shown on Graph 5, taking averages over the female and male health indicators over all age groups (the vertical axis measures income in terms of percentage increments). Taking the shape of this impact curve into account, as well as the health increments which actually occurred in each 5-year period, the approximate contribution of health increments to income in Latin America over the years 1950 to 1985 is shown on Graph 6 (the vertical axis measures income in terms of percentage increments from 1950). These are compared with the total economic growth experienced over the period (the background graph).

Final Remarks

With regard to the long-term relation between health and economic growth, our results, together with Mayer's (1999b) on Mexico, give new, strong evidence that there exists long-term conditional Granger causality from health to income in modern economic development. The horizon of this phenomenon is not exhausted by the available information in either study, which includes lags of up to 30 years here and 25 years in the study on Mexico.

The coefficients obtained for the impact on growth that the different age groups exert, are markedly consistent with results obtained in a similar study on Brazil for the period 1980-1990, in which the largest coefficients correspond to young age groups and the most significant to women (Mayer, 1999a). When the changes in health which actually occurred are taken into account, the implied effects of income also coincide with those of the study mentioned above for Mexico, in that adult health has a considerable long-term impact, which could be linked with intergenerational processes.

The impact of actual health increments at the longest lag of the analyzed period is considerable, having an order of magnitude of between 0.8 and 1.5% of annual economic growth in the Latin American case. These effects may occur through direct productivity increases, increased productivity and investment in education, increased female participation, reduced economic burden of disease and other channels. Some of these may be processes taking a long time to come into full effect, and may be conditional on some other economic factors such as a context of growth rather than stagnation. Further discussion can be found in World Health Organization (1999a) and in the conclusions to Mayer et al, 1999.

An interesting finding of this paper which merits further attention is that health improvements in the 50 to 75 year age group can contribute importantly to income growth. This means that the important health increments that have been achieved for this age group in Latin America since the 50's have led to productivity increments which must be associated with this group's human and social capital. Healthier grandparents may also contribute to strengthening the economy of younger families, burdening young adults less at the time when they most need to invest in their children. The health improvements achieved by this age group continue to be the largest at the present time. Thus, the phenomenon of increased longevity may in the earlier and ongoing stages of demographic transition and development lead to more productivity, even though in later stages it can lead to the increased economic burden of a larger retired population.

Our macroeconomic study includes a time horizon not used in previous studies of its kind on the role of health in economic growth. It also uses a much more precise measure of health than life expectancy, namely the probability of survival by age and gender groups. The results indicate that the contribution of health to economic performance are considerable, and should be taken into account by policy makers. Some of the channels of causation may be indirect. These need to be established more precisely in microeconomic studies, which, however, must take

into account a variety of long-term phenomena to fully account for the economic effects of health.

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