QUÆRERE VERUM

UNIVERSIDAD DE SAN ANDRÉS

Seminario del Departamento de Economía

"Economic Growth, Fertility, and the Quality of Childhood."

Marcelo Delajara

(Universidad Siglo XXI)

Martes 20 de junio de 2000
11:00 hs.

Aula Chica de Planta Baja

ECONOMIC GROWTH, FERTILITY, AND THE QUALITY OF CHILDHOOD*

Marcelo Delajara

December 1999

Abstract

We extend the neoclassical model of growth with endogenous fertility to analyze the evolution of the standard of living of children. The quality of childhood in Western economies, measured by the mean height-for-age of children, increased with economic growth during the last hundred and fifty years, but it declined and stagnated during industrial revolution times. There is evidence linking this evolution of heights to the demographic transition. We solve our model numerically and the results match the stylized facts well. The same relationship between fertility, income per capita, and children's heights emerges from the analysis of recent data from a cross-section of countries.

JEL Classification: E1, O1, J1, N3

* I thank Xavier Sala-i-Martin for comments and criticism. I also thank Gary S. Becker, Danilo Guaitoli, John Komlos, Pedro Mira and seminar participants at Pompeu Fabra, Tucumán, and meetings of the European Society for Population Economics in Amsterdam, Econometric Society in Cancún, International Economic Association in Buenos Aires, for useful comments. Remaining errors and shortcomings are mine alone.

I. INTRODUCTION

Recent research by Easterly [1999] has found that the relationship between quality of life indicators and income per capita is not always monotonic. In this paper we address this issue for an indicator of the quality of life of children, the average height-by-age profile of children.

This indicator is important for economic analysis because of the rich dynamics that has historically displayed. According to Komlos [1993] and Steckel [1995] children and adolescents in Western economies have experienced a sustained upward shift in their average height-by-age profile over the last 150 years, but heights declined and/or stagnated during the first part of the nineteenth century, coinciding with the initial stages of economic development. Another important finding is that a convergence in children's mean height-for-age is observed over regions, social classes and occupations during the last century.

To answer the question of why average children's height have displayed such particular pattern is the main objective of this paper, and should be seen as a contribution towards the determination of a more definite relationship between income per capita and measures of the quality of life.

Francis Galton [1988] noticed a hundred years ago that higher income households had fewer children but that they were of higher physical stature, and he concluded that these family characteristics were hereditary. Here we confront this view with the economic analysis of the relationship between height and fertility.

As discussed in Eveleth and Tanner [1976] it is a well established fact that the average height-by-age profile of children in a given economy is mainly related to the standard of living of children in that economy, what we shall call here the quality of childhood. The average height of children in a given economy must then be related to households' expenditures in their children. Then it seems possible to give an economic interpretation to the evolution of children's height.

In economics we stress the trade-off facing parents between the quality and the number of children they have. Actually Weir [1993] and Schneider [1996] associate the long-run changes in the mean height of Europeans with income growth and fertility decline, but they do not explain the temporary downturns in heights. In order to explain the evolution of children's height-for-age, we shall find of great help to take into account the contemporaneous evolution of fertility.

John Komlos [1989] highlights the role of the demographic explosion of the late eighteenth century in the height decline episodes for several European countries, but does not extend his study to modern times.

While there seems to be a consensus in considering long-run growth as the main cause behind the historical increases in children's heights, there is considerable dispute among researchers regarding the causes of the temporary downturns in mean heights.

The main episodes of height decline have been observed in England, Sweden and the USA in the first half of the nineteenth century. All these countries were growing in terms of per capita income at the time.

For the case of England, Komlos [1993] estimates that adolescent height falls for those who were born during the second half of the eighteenth century, it stagnates for those who were born in the first decades of the nineteenth century and starts its long-run increase for people who were born after the 1850s. These movements in heights were contemporaneous to the English demographic transition. According to Wrigley and Schofield [1989] cohort fertility rate increases until the late 1790s, it decreases thereafter, first slowly and after 1850 very fast. If we allow for a peak in actual fertility between 25 and 40 years later, then actual fertility changes have exactly the opposite sign of the contemporaneous changes in heights.

For the case of Sweden height data in Sandberg and Steckel [1988] and Sandberg and Steckel [1997], and the cohort fertility data in Eckstein et. al.[1998], reveal that between the 1730s and the 1770s fertility is low while between the 1770s and the 1810s it is high. Young men's height, on the other hand, grows for those who were born between about 1790 and the 1820s and then falls for those who were born between 1830s and 1850s. If we take the midpoint of each fertility regime as a reference, and assume that women have children in ages between 25 and 40, then young men who were born between 1875 and 1810 should have achieved a higher physical stature than men born between 1820 and 1850, since the former grew up in a period of low fertility, and this is precisely what the data indicates. In Sweden, the secular increase in heights starts for those who were born after 1850 coinciding with the definite decline in fertility.

The episodes of height decline in the United States seem to show a similar pattern. Komlos and Coclanis [1997] find a decline in the physical stature of the white people born in the second half of the 1830s for the State of Georgia (USA). Again, the evolution of heights seems to be correlated with changes in some demographic indicators. According to the U.S. Department of Commerce [1989] the dependency ratio (percentage of children 14-year-old and younger over total population) jumps more than 50 percent in Georgia during the 1840s and 1850s. It takes about a 100 years to go back to the level of the 1830s. There is evidence of height decline in other regions for the same period, and the behavior of fertility is also similar. The percentage of the 5 to 14 year-old children over total population increases about 10% in the Northeast, and almost 15 % in the North Central regions.

Therefore, this evidence seems to suggest that both the long-run increase and the temporary downturns in heights are part of the same phenomenon of economic growth and the changes it triggers in fertility.

In Section II we show that an extended version of the neoclassical theory of economic growth with endogenous fertility of Barro and Sala-i-Martin [1995] faithfully replicates all the features of the evolution of historical heights, including the downturns associated with initial stages of economic growth.

The extension amounts to including into the model a commodity representing the quality of childhood. This extension is done according to the definition of quality of children given by Gary Becker [1976].

As emphasized in Rosenzweig [1990] the replication of actual events does not constitute evidence for the hypothesis used in the model concerning the determinants or consequences of fertility decisions.

Therefore, in Section III we use contemporary data on fertility, income per capita, and children's height at age 10 to estimate the actual relationship between these variables across countries.

We find that the mean height of children is indeed intimately related to the level of fertility and income per capita across countries today. In our estimation we control for social arrangements, for race, for exogenous time shifts, and for the possibility that unobserved variables influencing income growth also influence vis-a-vis fertility and the height of children.

Previous empirical literature includes Steckel [1983] and Frongillo and Hanson [1995]. They resort to the same data source used here, but the objective of their estimations differs substantially from the one in this paper. In particular, they do not link fertility behavior to children's height.

In his pioneering article Steckel found that children's average height was positively related to income per capita with an elasticity of 0.27. As it is shown below this value for the income elasticity of height is too large. Steckel's warning against the use of cross-country estimates to explain historical heights no longer seems to hold if we control for other important determinants of height, like fertility and adult education.

Frongillo and Hanson find that income per capita does not explain much of the variability in children's heights across countries, instead they claim that all the variability is explained by race, food security and literacy. However, they do not test the statistical significance of the estimated coefficients.

In Steckel's work, as well as in Frongillo and Hanson's, height data of minorities are pooled together with country-wide measures of income and other variables, a practice that we avoid here because it can bias the estimates.

The rest of the paper is organized as follows. Section II introduces the model, the empirical analysis is done in section III, and section IV summarizes the main findings with their policy implications.

II. THE MODEL

A- Parental Preferences and the Quality of Children

In this section we show that a version of the neoclassical model of economic growth with endogenous fertility can indeed explain not only the long-run growth and convergence in children's heights but also the initial episodes of height decline.

We extend the growth and fertility model in Barro and Sala-i-Martin [1995]. In their model generations are linked through altruism. The representative parent in generation i is assumed to care for its own consumption C_i, the number of children it has n_i, and for the level of adult utility achieved by the children U_{i+1}. This future utility levels are discounted by a factor, $\Upsilon(n_i)$, which is inversely related to n_i.

Let the function $u(C_i, n_i)$ give the utility during adulthood from consumption and the presence of children, and $\Upsilon(n_i) n_i U_{i+1}$ be the discounted utility achieved by the next generation. Then total utility achieved by an individual in generation i is given by

$$U_i = u(C_i, n_i) + \Upsilon(n_i) n_i U_{i+1}$$

Barro and Sala-i-Martin's model replicates the demographic transition, and thus it already explains part of the empirical facts discussed above. This feature of the model is obtained because there is a trade-off between the *quality* and the *quantity* of children.

Gary Becker [1976] defines the *quality* of children as follows:

> A family must determine not only how many children it has but also the amount spent on them [...] I will call more expensive children "higher quality" children, just as Cadillacs are called higher quality cars than Chevrolets. [...] If more is voluntarily spent on one child than on another, it is because the parents obtain additional utility from the additional expenditure and it is this additional utility which we call higher "quality".

Now, total utility U_i may be increased through different kinds of expenditures on children. I shall distinguish here between those parental expenditures that increase $u(\cdot)$ from those that increase it indirectly via the discounted value of U_{i+1}.

Typically it is assumed that higher quality children are those who achieve larger utility during adulthood because they provide their parents with higher discounted utility. In this case, larger adult consumption of children is considered an acceptable indicator of higher quality children: it increases parental utility, and this increase is mainly the result of larger parental expenditures in child education.

By a similar reasoning, children of higher mean stature should be also considered of higher quality because higher mean height is the result of larger parental expenditures in the quality of life during childhood.

It is reasonable to assume that these kind of parental expenditures on children rise $u(\cdot)$, the utility derived from adult consumption and the presence of children, while they do not necessarily increase the future consumption of children.

Barro and Sala-i-Martin emphasize that their formulation "does not distinguish the consumption of children during their childhood from that of their parents". It is precisely here where we depart from this model, since we want to analyze the evolution of the standard of living of children. It is implicit in their argument that they consider adult consumption C as a comprehensive commodity which includes *all* those commodities associated with adulthood expenditures: those which relate specifically to adult consumption and those which relate to children's living standards.

Therefore, let's assume here that the composite commodity C_i is a function of adult's own consumption c_i and the contemporary standard of living of each child q_i. In particular we assume that

$$C_i = c_i^{\sigma} q_i^{1-\sigma}$$

with $0 < \sigma < 1$.

We associate standard of living of the representative child with the average nutritional status of children, which in practice is measured by the mean height-by-age criterium. In what follows we use the term quality of childhood to refer to the standard of living of children.

We follow the literature and adopt the following formulation: a constant elasticity form for the discount factor

$$\Upsilon(n_i) = \Upsilon n_i^{\epsilon},$$

and for the utility function

$$u(c,q,n) = \frac{[(c^{\sigma} q^{1-\sigma} n^{\psi})^{1-\theta} - 1]}{(1-\theta)}$$

Let's define N_j as the size of the family in generation j, let $N_i = 1$ and $N_j = \prod_{k=i}^{j-1} n_k$ for $j > i$, and assume $\psi = (1-\epsilon)/(1-\theta) > 0$.

Then, operating forward in the discrete time utility function above we get the dynastic continuous form

$$U = \int_0^{\infty} e^{-\rho t} \left(\frac{(N^{\psi} c^{\sigma} q^{1-\sigma} n^{\psi})^{1-\theta} - 1}{1-\theta} \right) dt \tag{1}$$

I assume infant mortality is exogenous and equal to zero for simplicity (the important results do not depend on this assumption), so that utility depends on net fertility n.

The parameter ρ, $(0 < \rho < 1)$ is the part of the discount factor which does not depend on the level of birth rates, the other part has been incorporated in the utility function itself as represented by N^{Ψ}.

B- Home Production of Childhood's Quality

We assume that the quality of childhood is produced at home.

There is a physical cost function by which each unit of q requires λ units of resources. These costs mainly represent parental expenditures on child's food consumption and health care.

It is also assumed that independently of the level of the quality of childhood or the level of human capital of the family, there is a fixed cost per child of Λ units of resources. These are basically fixed child-bearing costs, which include the costs of avoiding child mortality.

C- Household's Budget Constraint

As in Barro and Sala-i-Martin [1995], the stock of human and physical capital of the family is given by K. The rate of return to family capital is r. Each member of the family supplies inelastically 1 unit of working time and receives a wage w per unit of time. Then, total family income is given by $wN + rK$.

This income is split up among alternative uses: $\dot{K}$ is family savings in the form of physical and human capital, cN is family's adult consumption, and $(\Lambda + \lambda q)nN$ are total resources spent on newborns and on the quality of childhood.

The *per capita* budget constraint is given by

$$c + (\Lambda + \lambda q)n + \dot{k} = w + (r - n)k \tag{2}$$

At each instant decisions are taken for a given size of the family, N, and for a given level of the stock of family capital, K.

The change in the number of descendants per unit of time is given by the following law of population growth

$$\dot{N} = nN \tag{3}$$

The model is completed with the production side of the economy. There is a neo-classical Cobb-Douglas production technology which implies that $w = (1 - \alpha)Ak^{\alpha}$ and $r = \alpha Ak^{\alpha - 1} - \delta$. I assume, for simplicity, no technological change here.

D- Household's Optimization Problem and Equilibrium Conditions

The representative household's problem is to choose the paths of the control variables c, q, and n that maximize (1) subject to (2) and (3).

Assuming that $\theta = 1$, the solution of the model is characterized by the following system of equations.

$$\dot{k} = Ak^{\alpha} - (n + \delta)k - c - (\Lambda + \lambda q)n \tag{4}$$

$$\frac{\dot{c}}{c} = \alpha A k^{\alpha-1} - (n + \delta + \rho) \tag{5}$$

are the first order differential equations for capital accumulation and adult consumption growth, and

$$n = \frac{(\sigma + \phi - 1)(c/k)}{\sigma(1 + \Lambda/k) - \frac{\psi}{\rho}(c/k)} \tag{6}$$

and

$$q = \frac{1 - \sigma\; c}{\sigma\lambda\; n} \tag{7}$$

give the fertility and quality of childhood levels at each point in time for given values of the stock capital. The law of motion of population in (3) closes the system.

E- Numerical Solution

This model can not be solved analytically. I use the numerical method developed by Mulligan and Sala-i-Martin [1991] to solve dynamic continuous time models.

There is a key aspect of this system which allows a numerical solution to be possible. One can substitute (6) and (7) for n and q in (4) and (5) to obtain an autonomous system of differential equations in c and k.

The algorithm then gives us the policy function of adult consumption $c(k)$ and the time path of capital stock $k(t)$ that solve this autonomous system. Then we plug these results back into (7) and (6) to find the policy function of childhood's quality $q(k)$ and the policy function of fertility $n(k)$.

The parameter values used in the simulation were kept as similar as possible to the ones used in previous literature.

$\alpha = .68 \quad A = 1 \quad \rho = .04 \quad \delta = .05 \quad \psi = .20 \quad \phi = .20 \quad \sigma = .90 \quad \Lambda = 50 \quad \lambda = 1$

For the new parameter σ we did not have any previous indicative value. The results of the simulation replicate the empirical evidence when $\sigma = 0.9$

F- Transitional Dynamics

The solution is shown in Figures I and II. The policy functions for fertility, $n(k)$, and the quality of childhood, $q(k)$ are shown in Figure I.

Figure I here

The model replicates very well the stylized facts of the evolution of adult consumption, fertility, and the quality of childhood. In particular, it replicates the downturn in the quality of childhood observed in the initial stages of economic growth.

The model attributes this phenomenon to three features of economic development. First, there are fixed costs in the production of children; second, for a given level of fertility, the quality of childhood in a given generation is proportional to the level of consumption of the adults; third, for a given level of adult consumption, a larger number of children per household implies a lower level of expenditures in the quality of childhood per child.

These three features, embodied in equations (6) and (7), interact to cause the transitional dynamics. When income per capita is low the fixed cost of children is relatively large and fertility is kept low. However, income grows fast at the initial stages of economic growth, this lowers the importance of these fixed costs, and fertility increases. Fertility grows faster than adult consumption when the stock of capital is low, this causes the quality of childhood to decline at the initial levels of economic development.

At larger levels of capital, the weight of the fixed cost in the production of children is not important, and fertility would keep growing if there were no other costs of children. However, households want the quality of childhood to be proportional to adult consumption. As income and adult consumption grow, households invest at lot more resources in the quality of childhood. The increase in the quality of childhood makes each new born more expensive, and after a given level of income, fertility starts to decline towards a lower steady state value, while the quality of childhood increases and converges towards its steady state.

The adult consumption policy, $c(k)$, is shown in Figure II. Adult consumption grows monotonically over time with the stock of capital.

Figure II here

The solution of the model is completed with the analysis of the behavior of k over time. Figure II displays the time path of the stock of human and physical capital. Capital grows over time, and converges to the steady state.

These theoretical results show that the neoclassical model can be extended to explain the evolution of the standard of living of children, as documented by the historical evolution of the mean height-by-age profile of children.

III. EMPIRICAL ANALYSIS

This section uses data from a cross-section of countries to estimate the actual relationship between income per capita, fertility, and the average height of children.

The empirical model estimated below relies on the particular features of the theoretical model discussed in the previous section.

First, there is a non-monotonic relationship between fertility and income per capita. Second, the levels of fertility and quality of childhood chosen in a given period are a function of the level of income per capita in that period -and independent of the dynamics of capital and consumption. Third, quality and quantity are determined simultaneously .

The assumption that fertility and childhood's quality are control variables is important because, granted that countries differ only in the size of the costs of children but not in the form of the policy functions of fertility and quality of childhood, the predictions of the model hold not only over time but also in a cross section of countries.

Based on this framework the objective will be to estimate particular specifications of the following system of two equations

$$FERT_i = A_1 P_i^f + A_2 H_i + A_3 INC_i + A_4 INC_i^2 + \varepsilon_{f,i} \tag{8}$$

$$H_i = B_1 D_i + B_2 P_i^h + B_3 FERT_i + B_4 INC_i + \varepsilon_{h,i} \tag{9}$$

where $FERT$ and H are the logarithm of fertility and the logarithm of height, respectively; INC is the logarithm of income per capita; P is a vector of the variables that proxy for the fixed costs of children; D are dummy variables for race; and ε_f and ε_h are the disturbance terms in the regression.

A- Data and Model Identification

The purpose here is both to identify the model in equations (8) and (9), and to show the basic features of the data. For expositional clarity it is convenient to do both things at the same time.

Heights: The data on the mean heights of children are taken from Eveleth and Tanner [1976] and Eveleth and Tanner [1990]. They report the average height of children, by age and ethnic group, for several countries in all continents. For each study we know the year of birth of the cohort of measured children. We work here with the heights of 10-year-old boys.

In Eveleth and Tanner's data not all the studies are representative of national levels of height. To be sure that representative figures are used, we shall only use the data on heights for those racial groups which constitute a majority in a given economy, and data from those studies which report average heights that are representative of national trends. We have 48 observations that satisfy these requirements.

We work with the heights of 10-year-old boys for two reasons. Firstly, we are trying to avoid the differing patterns of height growth that occur at previous and later ages, when the rate of human growth of children is considerably faster. Secondly, height data is not always available at younger and older ages for as many countries as we analyze here. For six of the countries the average height is the linear average of the mean heights reported for rich and poor children.

The list with the 48 countries and their children's height in centimeters (cm) is shown in Table I.

Table I here

Fertility: The data on fertility is also shown in Table I. We use net fertility which is defined as total fertility multiplied by one minus the under-five mortality rate. Net fertility in a given country is computed for the reported year of birth of the children in that country. The data on total fertility is from the World Development Report 1994, and mortality rates are from World Resources 1994-1995 and the World Development Report 1978.

Income per Capita: Income in a given economy will be the average of the GDP per capita for the period going from cohort birth to cohort measurement. The source of the data is The Penn World Table 5.6. We use per capita GDP in constant dollars (expressed in international prices of 1985) so that the values for income per capita can be compared across countries and over time. The data on income is also shown in Table 1.

The theory predicts the way fertility and height should interact with each other and with income, given the fixed costs of children in matrix P. I use variables such as adults' literacy rates, urbanization and religious affiliation as proxies for these costs.

Adults' Education: We assume that adults' educational level affects the costs of both the quality of childhood and the quantity of children. Adults' education is measured by the adult literacy rates found in the country at the reported year of birth of the children in that country. We denote this variable LIT. Data on literacy rates are taken from the World Development Report 1978 and Human Development Report 1994.

Adult literacy is expected to have a significant and positive effect on heights, for a given level of fertility. According to Becker [1976] the cost of quality falls with improving parental skills in rearing and nurturing of children; these skills increase with the level of education of parents.

For a given height of children, parental education and fertility are expected to be negatively related. The higher the levels of education, the higher the opportunity cost of maternity, and hence the lower the fertility rate. We also expect literacy rates to be negatively related to fertility because it improves parental access to contraceptive methods, thus increasing the price of the number of children as parents can come closer to their desired number of offsprings.

Share of Urban Population: Let's denote $URBAN$ the percentage of urban over total population in country i at about the reported year of birth of the children in that country. The data on the share of urban population are taken from the World Development Report 1978 and Human Development Report 1994.

We assume that the percentage of urban population proxies for a part of the costs of fertility. The cost of children, given the quality of childhood, seems to be larger in urban than in rural areas for several reasons, such as that urban children contribute less to household income than rural children, and also because lower costs of avoiding pregnancies and deliveries in urban than in rural areas.

Religion: Let's denote R the religion variable that we introduce in the model to control for those social and cultural aspects that might be affecting the costs of children. We assume that religion affects the costs of producing children, independent of the quality of childhood. Religious beliefs affect fertility most likely through the psychic and monetary costs of avoiding pregnancies and deliveries.

Data on religious practices can be found in The Cambridge Factfinder 1993. We classify the countries in four groups according to the religious beliefs of the majority of population: Roman Catholic, Christian non Catholic (category omitted in the regressions), Muslims and the rest of religious groups. Thus there are four variables for religion, each taking the value 1 if the majority of population professes a given religion, and 0 otherwise.

Ethnic Group: The variables D are dummy variables which signal the race of children in country i. The main purpose of these variables is to control for any genetic-based differences in children heights that may remain between populations after controlling for the socioeconomic variables.

We follow the classification of populations according to their race proposed by Eveleth and Tanner. There are six groups indexed by j, with $j = 1, 2, 3, 4, 5$ and 6. The variable Dj_i takes the value 1 if the observation i refers to children in race group j (see Table II).

In our sample European children average 138 cm, European descendants 135 cm, followed by Sub-Sahara African and Indo-Mediterranean children with 130 cm, children from Pacific Ocean Islands with 127.5 cm, and Asiatic children with 126.5 cm.

More on the Identifying Restrictions: We have assumed that heights might be affected by race, but that no human group is more fertile than another just because of racial considerations. Indeed, although heredity is among the biological determinants of fecundity at the individual level, this is not true across large populations groups, like the ones we distinguish in the analysis.

Once we control for adult literacy and income per capita in equation (9), there is no reason to assume that higher shares of urban population would be associated with taller children. This variable is not measuring the quality of life of children in cities, it is only a proxy for the degree to which adults face on average larger cost of children of given quality, so we assume that the share of urban population does not enter into the determination of height in the model.

We assumed that religion affects the quality of childhood only indirectly through its effect on fertility. Religions are notable for their attempts to affect fertility choice by imposing strong restrictions on sexual behavior. It is well known that societies differ remarkably in what they consider socially desirable and undesirable in terms of sexual behavior and consequently differ in what they attempt to prevent or promote. So we conclude that religion is more likely to affect directly the costs of quantity rather than the quality of childhood.

Creditworthiness: As mentioned, we estimate one of the regressions with an instrument for income per capita. We need a variable highly correlated with income per capita but unrelated to the part of fertility and the height of children not explained either by , religion, parents' literacy rate, urbanization, or income. We choose the Euromoney Country Creditworthiness Rating ($CRDT$) of the World Development Indicators 1997. This is an indicator of the riskiness of investing in a given economy.

Stochastic Disturbances: Finally, ε_f and ε_h are the disturbance terms assumed to have standard stochastic properties; i.e. The disturbance terms ε_f and ε_h are assumed to be randomly drawn from an bivariate distribution, uncorrelated with the predetermined variables, to have a mean of zero and constant variance, and to be uncorrelated between them.

B- Estimation

Given the identifying assumptions discussed above, the system of equations (8) and (9) can be rewritten as follows:

$$FERT_i = A_1 R_i + A_2 LIT_i + A_3 URBAN_i + A_4 H_i + A_5 INC_i + A_6 INC_i^2 + \varepsilon_{f,i} \qquad (10)$$

$$H_i = B_1 D_i + B_2 LIT_i + B_3 FERT_i + B_4 INC_i + \varepsilon_{h,i} \qquad (11)$$

Notice that because $FERT$ and H appear on the right hand side of the equations, they can not be estimated using OLS. Also notice that the number of predetermined variables excluded from each equation is larger than 1, the number of included endogenous variables, and so each equation is said to be overidentified.

Therefore, we estimate the system one equation at a time with a two-stage least squares (2SLS) method which involves the use of instrumental variables for fertility and heights. In this method, the instrument for the endogenous variable in a given regression is the predicted value of that variable given all the predetermined variables in the system.

C- Results

The main results from the 2SLS estimation shown in Table II, A and B, refer to the role of income in the determination of fertility and heights, and the relationship between average heights and fertility.

Table II here

Specification 1 shows that income has a significant effect on the average height of children and the fertility of women.

We estimate a significant quadratic relationship between fertility and per capita income. As income grows, fertility first increases, reaches a maximum and then it decreases with further increases in income. The estimated income elasticity is given by $1.24 - 0.158 * INC$. Thus, there is an income per capita level below which the income elasticity of fertility is positive, and above which it is negative. This estimated threshold point is found at an income per capita of 2560 (in 1985 international) dollars.

We estimate a direct effect of income per capita on the average height of children that is linear, positive and significant. The income elasticity of height is 0.01, much lower than the 0.27 reported by Steckel [1983]. This means that a 10% increase in income per capita, holding everything else constant, causes children's height to increase 0.1%.

The reader should bear in mind that this is only the direct effect of a change in income on height. There is also an indirect effect of income changes on height working through fertility. This indirect effect may be positive or negative.

To see this notice from Table II that fertility and heights are negatively related, and recall that increases in income raise fertility at low levels of income and lower it at large levels of income.

In Table IIA, specification 1 shows that the estimated height elasticity of net fertility is -3.52. This means that a desired 10% increase in the quality of childhood implies a direct reduction in fertility of about 35%. Table IIB shows in turn that the fertility elasticity of height is -0.04. That is, for each 10% decrease in fertility, there is an increase in height of about 0.4%.

Therefore, at low levels of income, per capita income growth raises heights only if the direct effect is larger than the indirect effect, while at large levels of income both the direct and the indirect effects are positive.

We can find the threshold value of income per capita up to which income growth reduces heights: it is the income level, y^*, at which the direct effect is exactly compensated by the indirect effect. Then y^* should satisfy $0.01 - 0.0445 * (1.24 - 0.158 * \ln y^*) = 0$; then $y^* \simeq 620$ (1985 Int'l) dollars.

A slightly different result is obtained in specification 2 when we estimate the model with the instrument $CRDT$ for income per capita. We estimate the model with an instrument for income to control for those unobserved forces influencing income changes that might also jointly affect fertility and heights.

In this case, the direct effect of income on heights disappears, while the indirect effect remains and becomes stronger. We also find that the quadratic relationship between income and fertility remains significant, but the coefficient of heights on the fertility equation is not significantly different from zero.

Then, a somewhat different picture comes up in which changes in income would affect fertility as before, but then fertility would be the only determinant of the average height of children. Therefore, in this specification any increase in income that raises (reduces) fertility would decrease (increase) heights.

The important result is that, independently of the specification one considers, a range of income is found in which income growth increases fertility and lowers the average height of children.

Other results refer to the sign and significance of the variables that proxy for the fixed costs of children.

Literacy rates affect average heights and fertility in the expected way. The coefficient of literacy is positive and significant in the height equations for all cases.

Adult literacy rates and the percentage of urban population are both negatively related to fertility. However, for some specifications their coefficients are not significant. The problem seems to be one of multicollinearity, because literacy's significance increases when $URBAN$ is drop out of the fertility regression in specification 3; the correlation between both variables is 0.84.

Two of the race dummy variables, $D3$ and $D4$, which correspond to African and Asiatic groups, respectively, turn out to be significant in the estimation of heights (Table IIB).

Once we control for GDP per capita, fertility and adult education, African children are predicted to be about 1 cm *taller*, and Asiatics about 1 cm shorter, than Europeans. We mentioned before that European children are about 8 cm taller than African children in our sample, for the case of Asiatics this difference is 11.8 cm. Therefore, the genetic component explains very little of this difference.

For the case of religion, the results are shown in Table IIA. We find that religion does not have any explanatory value for fertility once we control for GDP per capita, adult education, urbanization, and the quality of childhood.

In our sample, boys' mean height at age 10 has been measured at different years in different countries (see Table I). However, there is a span of 25 years between the earliest and the latest year of measurement. In order to ensure that our estimates depend exclusively on the relationship between income levels, fertility and height, and that they are independent of time, we introduce in specification 4 a time trend variable called *Time*.

The results show that nothing changes once we control for the year of measurement. The coefficient of *Time* is insignificant in both equations. We could interpret *time* as a *test* of exogenous time shifts in fertility and heights of the type discussed in Easterly [1999], and conclude that in our case global socioeconomic development is not more important than own country growth for the evolution of these variables.

D- Specification Tests

We performed specification tests to check for the assumed exogeneity of $URBAN$, LIT and INC. The test is Spencer and Berk's Wald statistic test performed at the equation level (Greene [1993]). We checked for the exogeneity of each variable at a time. The Wald statistics has a Chi-squared distribution with one degree of freedom. We would reject the null hypothesis of exogeneity at the 5 percent level if the estimated statistic were larger than 3.84. Upon performing the test we find that the statistic takes the values 0.96, 1.89 and 3.77 for $URBAN$, INC and LIT respectively, so I can not reject the hypothesis of the exogeneity of these variables.

IV. CONCLUSION

We started by asking whether economics could explain the evolution of the quality of childhood as measured by the historical evolution of children's height-by-age. With the objective of answering this question, we extended the neoclassical model of growth with endogenous fertility to include childhood's quality, and found that the model's transitional dynamics are indeed consistent with the evolution of heights.

We also undertook an empirical analysis of contemporary children's heights. The findings support the predictions of the theoretical model, and accord well with the historical stylized facts. As income per capita increases, fertility declines and the mean height of children rises, independently of social arrangements and race; however, at low levels of income per capita, income growth raises fertility and reduces the average height of children.

A limitation of the results is that we cannot definitely conclude whether there is a direct effect of income per capita on the average height of children, in addition to the indirect effect via changes in fertility.

Other results are that race explains part of the differences in children's average height for the case of Sub-Saharan and Asiatic children in our sample, however, most of the difference is explained by income, fertility and adult literacy rates. Religion is not an important determinant of height and fertility once we control for adult literacy. We neither find evidence that changes in fertility or children's heights could be explained by exogenous time shifts.

The finding that, in very poor countries, an exogenous increase in income per capita may indeed reduce heights and increase fertility casts doubts on the usefulness of international income transfers to foster childhood quality in those countries.

UNIVERSIDAD SIGLO 21. CÓRDOBA, ARGENTINA.

REFERENCES

1. Barro, Robert J., and Xavier Sala-i-Martin, *Economic Growth*, (New York: McGraw-Hill, 1995).

2. Becker, Gary S., "An Economic Analysis of Fertility", in Gary S. Becker, *The Economic Approach to Human Behavior*, (Chicago: University of Chicago Press, 1976).

3. Easterly, William, "Life During Growth", *Journal of Economic Growth*, IV, 3. (1999), 239-276.

4. Eckstein, Zvi, Pedro Mira, and Kenneth I. Wolpin, "A Quantitative Analysis of Swedish Fertility Dynamics: 1751-1990", (Madrid, CEMFI manuscript, 1998).

5. Eveleth, Phyllis B., and James M.Tanner, *Worldwide Variation in Human Growth*, (Cambridge, England: Cambridge University Press ,1976).

6. ——, and —— *Worldwide Variation in Human Growth*, (Cambridge, England: Cambridge University Press ,1990).

7. Frongillo E.A. Jr, and K.M.P. Hanson, "Determinants of Variability Among Nations in Child Growth", *Annals of Human Biology*, XXII, 5, (1995), 395-411.

8. Galton, Francis, *Herencia y eugenesia*, (Madrid: Alianza Editorial,1988).

9. Greene, William G., *Econometric Analysis*, 2nd Edition, (New York: Macmillan Publishing Company, 1993).

10. Komlos, John, *Nutrition and Economic Development in the Eighteenth-Century Habsburg Monarchy: An Anthropometric History*, (Princeton: Princeton University Press, 1989).

11. ——, "The Secular Trend in the Biological Standard of Living in the United Kingdom, 1730-1860", *Economic History Review*, XLVI, 1, (February 1993), 115-44.

12. Komlos, John, and Peter Coclanis, "On the Puzzling Cycle in the Biological Standard of Living: The Case of Antebellum Georgia", *Explorations in Economic History*, XXXIV, (1997), 433-459.

13. Mulligan, Casey, and Xavier Sala-i-Martin, "A Note on the Time-Elimination Method for Solving Recursive Economic Models", NBER Technical Working Paper no 166, (1991).

14. Rosenzweig, Mark, "Population Growth and Human Capital Investments: Theory and Evidence", *Journal of Political Economy*, XCVIII, 5, pt.2 (1990), S38-S70.

15. Sandberg, Lars G., and Richard H. Steckel,"Overpopulation and Malnutrition Rediscovered: Hard Times in Nineteenth Century Sweden", *Explorations in Economic History*, XXV, 1, (1988), 1-19.

16. ______, and ______. "Heights and Economic History: The Swedish Case", *Annals of Human Biology*, XIV, (1997), 101-110.

17. Schneider, Ryan, "Historical Note on Height and Parental Consumption Decisions", *Economics Letters*, L, (1996), 279-283.

18. Steckel, Richard H., "Height and Per Capita Income", *Historical Methods*, XVI, 1, (Winter 1983), 1-7.

19. __________, "Stature and the Standard of Living", *Journal of Economic Literature*, XXXIII, (December 1995), 1903-1940.

20. Weir, David R., "Parental Consumption Decisions and Child Health During the Early French Fertility Decline, 1790-1914", *The Journal of Economic History*, LIII, (June 1993), 259-74.

21. Wrigley, E.A. and R.S. Schofield, *The Population History of England, 1541-1871*, (Cambridge, England: Cambridge University Press, 1989).

22. U.S. Department of Commerce. Bureau of the Census, *Historical Statistics of the United States. Colonial Times to 1970*, (1989).

Table I
Countries Ranked by Height at Age 10, with Fertility and GDP

	Country	Year	D	Height	Fertility	GDP
1	Netherlands	1980	1	142.2	2.3	10512.3
2	West Germany	1978	1	141.4	1.9	10162.9
3	Switzerland	1972	1	140.4	2.3	11950.8
4	Norway	1975	1	140.4	2.4	8380.8
5	Sweden	1970	1	140.1	2.2	7768.2
6	Denmark	1977	1	139.1	2.0	10174.5
7	Hungary	1985	1	138.6	1.8	5042.7
8	Greece	1983	1	138.3	1.9	5650.1
9	Italy	1970	1	138.0	2.3	6084.0
10	Australia	1985	2	138.0	1.9	12477.4
11	New Zealand	1969	2	138.0	3.7	8584.7
12	United States	1980	2	137.7	2.2	14459.4
13	Canada	1969	2	137.2	3.7	8478.9
14	United Kingdom	1981	1	136.6	2.2	9737.1
15	Ireland	1980	1	136.2	3.7	6000.0
16	Belgium	1961	1	136.0	2.5	5094.0
17	Argentina	1981	2	136.0	2.9	6066.9
18	France	1980	1	136.0	2.3	10705.6
19	Turkey	1970	5	135.6	5.0	1922.3
20	Japan	1980	4	135.0	2.0	8758.6
21	Hong Kong	1984	4	134.9	2.0	8279.6
22	Costa Rica	1969	2	133.9	6.1	2395.8
23	Uruguay	1962	2	133.2	2.8	4059.4
24	Botswana	1985	3	133.0	5.8	1827.2
25	Brazil	1969	2	132.9	5.1	1949.9
26	Spain	1965	1	132.7	2.6	3498.4
27	Tanzania	1965	3	132.5	5.1	336.5
28	Saudi Arabia	1985	5	132.5	6.6	11823.9
29	Fiji	1968	6	132.5	5.5	2214.6
30	Nigeria	1970	3	132.4	5.5	585.7
31	Egypt	1963	5	131.8	5.2	780.7
32	Sudan	1968	3	131.6	4.8	817.0
33	Tunisia	1973	5	131.6	5.4	1400.6
34	Ghana	1965	3	131.5	5.4	894.7
35	Chile	1974	2	131.2	4.4	3570.0
36	Zaire	1970	3	130.4	4.3	581.1
37	Liberia	1961	3	128.5	4.7	728.5
38	Gambia	1975	3	126.8	4.7	791.9
39	Ethiopia	1965	5	126.5	4.8	262.2
40	Kenya	1980	3	126.0	6.8	846.3
41	South Korea	1965	4	125.8	5.0	947.6
42	Philippines	1964	4	125.0	6.1	1122.0
43	Mexico	1977	4	124.5	5.9	4440.8
44	Bolivia	1964	4	124.1	5.0	1185.8
45	India	1965	5	124.0	4.6	750.3
46	New Guinea	1970	6	122.4	4.5	1672.7

Table II

A — Dependent Variable: **Fertility**

Regressors	1	2	3	4
Constant	14.1223	7.5033	13.4330	13.6642
	8.2771	*11.9224*	*8.6522*	*7.6395*
R2	0.1345	0.1493	0.1078	0.1329
	0.0981	*0.1074*	*0.1062*	*0.0986*
R3	0.0312	-0.0079	0.0162	0.0323
	0.0987	*0.1198*	*0.0922*	*0.0976*
R4	-0.0010	-0.0015	-0.0013	-0.0010
	0.0013	*0.0015*	*0.0014*	*0.0013*
Time				-0.0002
				0.0068
Literacy	-0.0044	-0.0049	-0.0055	-0.0045
	0.0028	*0.0041*	*0.0028*	*0.0028*
Urban Pop.	-0.0031	-0.0032		-0.0031
	0.0028	0.0038		*0.0026*
Height	-3.5174	-2.8419	-3.3844	-3.4273
	1.5587	*1.9090*	*1.6212*	*1.4396*
Income	1.2423	2.1201	1.2842	1.2486
	0.3784	*1.0606*	*0.4029*	*0.3858*
Income^2	-0.0791	-0.1352	-0.0847	-0.0795
	0.0249	*0.0666*	*0.0276*	*0.0262*
R^2	0.68	0.65	0.67	0.67

B — Dependent Variable: **Height**

Regressors	1	2	3	4
Constant	4.8252	4.8532	4.8381	4.8012
	0.0552	*0.0581*	*0.0637*	*0.0526*
D2	0.0025	0.0021	0.0014	0.0018
	0.0081	*0.0067*	*0.0090*	*0.0080*
D3	0.0355	0.0340	0.0364	0.0417
	0.0146	*0.0137*	*0.0152*	*0.0157*
D4	-0.0337	-0.0354	-0.0319	-0.0327
	0.0093	*0.0075*	*0.0101*	*0.0098*
D5	0.0277	0.0265	0.0291	0.0319
	0.0160	*0.0146*	*0.0172*	*0.0178*
D6	-0.0038	-0.0473	-0.0023	-0.0012
	0.0248	*0.0100*	*0.0262*	*0.0251*
Time				-0.0001
				0.0005
Literacy	0.0005	0.0005	0.0004	0.0005
	0.0002	*0.0002*	*0.0002*	*0.0002*
Fertility	-0.0445	-0.0457	-0.0502	-0.0421
	0.0197	*0.0140*	*0.0228*	*0.0189*
Income	0.0109	0.0072	0.0103	0.0136
	0.0036	*0.0062*	*0.0041*	*0.0042*
R^2	0.79	0.82	0.79	0.78

Note: Standard errors in italics

References

R1: Non-Catholic Christian
R2: Muslin
R3: Roman Catholic
R4: Other

D1: European
D2: European Descenda
D3: Sub-Sahara African
D4: Asian
D5: Indo-Mediterranean
D6: Pacific

Figure I

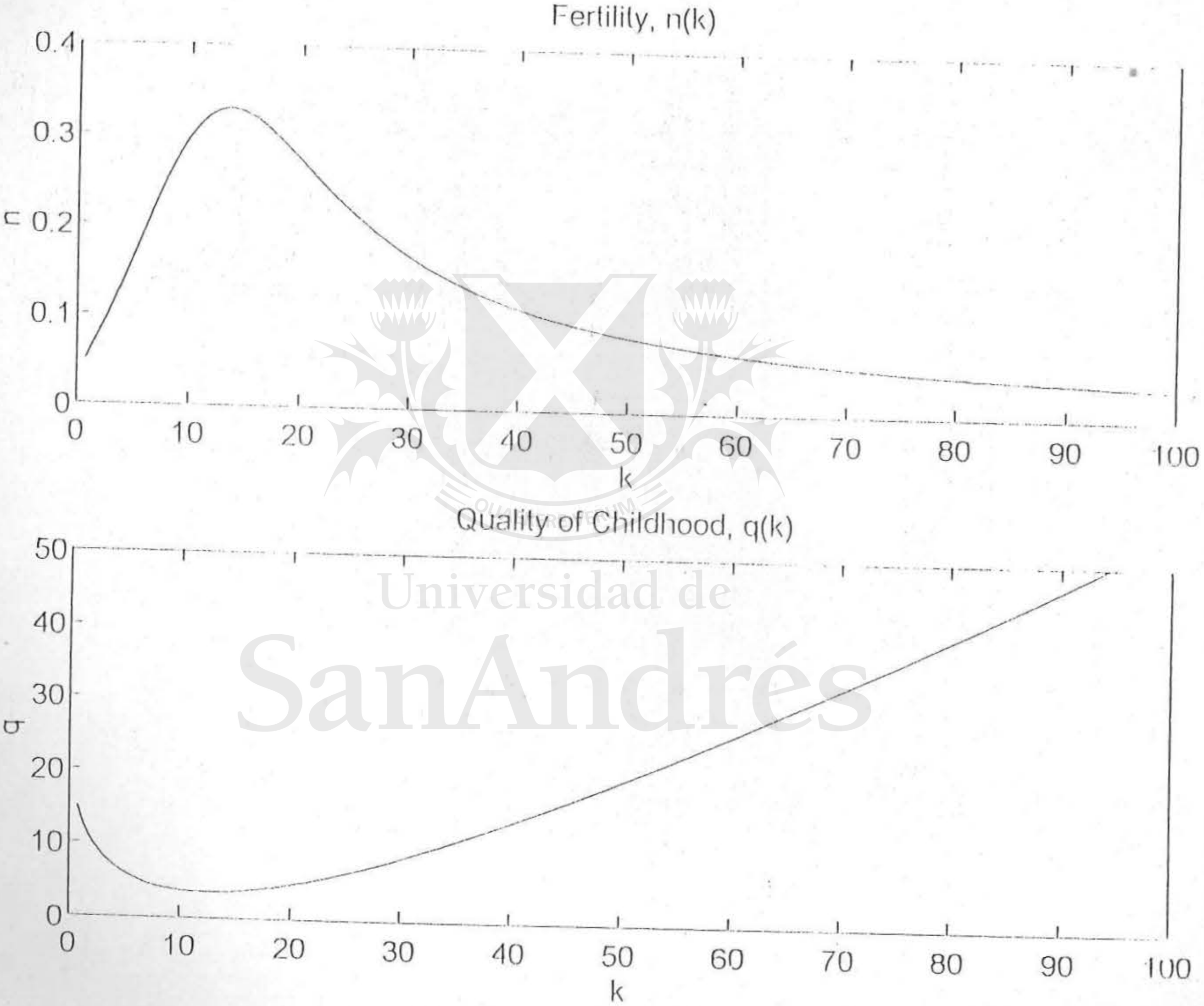
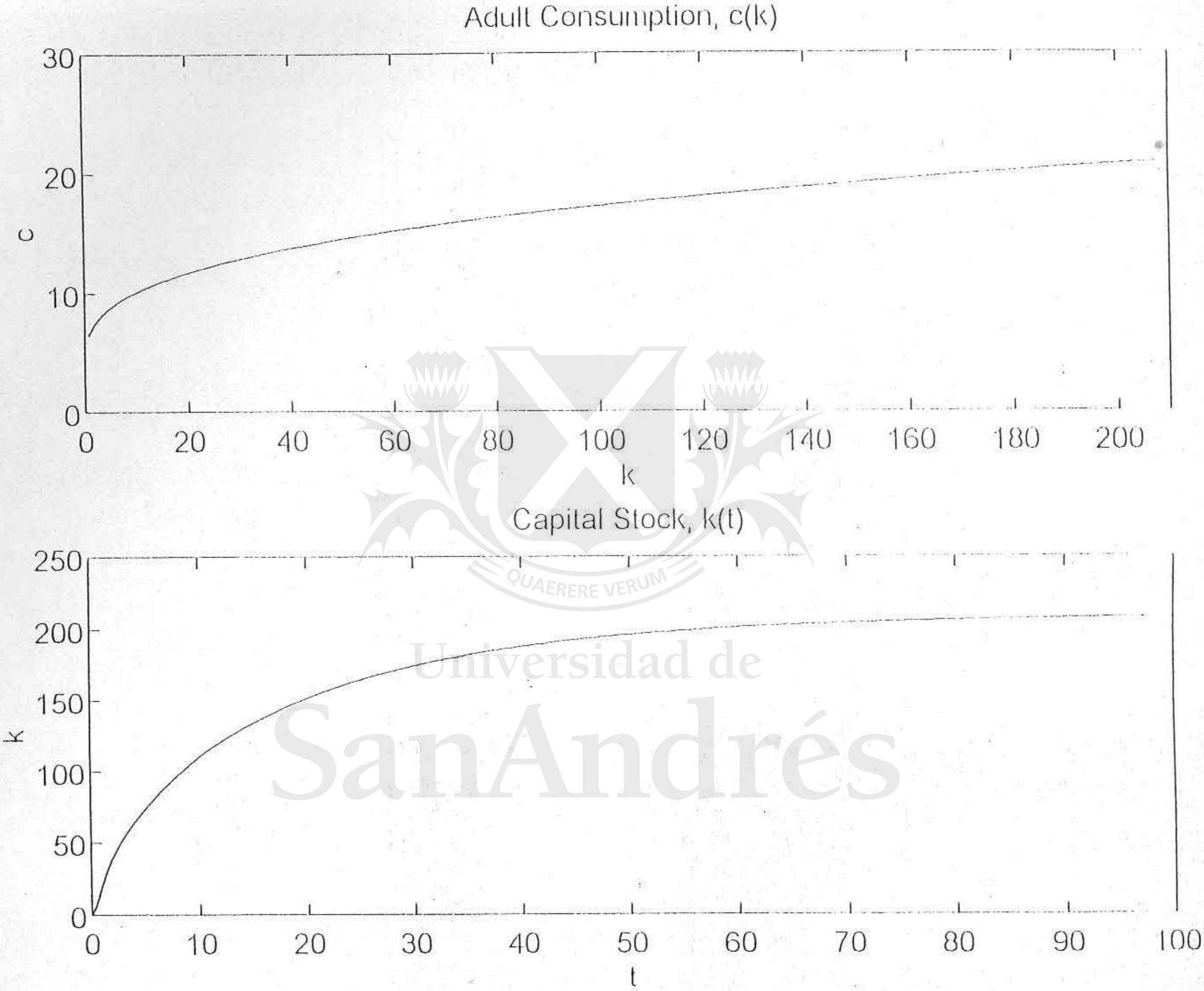

Fertility, n(k)
0.4
0.3
n 0.2
0.1
0
0 10 20 30 40 50 60 70 80 90 100
k
Quality of Childhood, q(k)
50
40
30
q
20
10
0
0 10 20 30 40 50 60 70 80 90 100
k

Figure II


Adult Consumption, c(k)
30
20
10
0
c
0
20
40
60
80
100
120
140
160
180
200
k
Capital Stock, k(t)
250
200
150
100
50
0
k
0
10
20
30
40
50
60
70
80
90
100
t