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IMPACT OF PER CAPITA INCOME GROWTH ON POPULATION GROWTH: A CROSS SECTIONAL ANALYSIS

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A number of writers contend that rising per capita incomes will reduce birth rates and solve problems of high population growth in developing countries (see, for example, Clark and Simon). This contention is attractive because family planning programmes that may conflict with some religious and ethical values need not be implemented. But the contention is dangerous if it is wrong. Even if developing countries temporarily achieve per capita income gains, failure of such gains to retard population growth can eventually offset advances in total income and relegate developing countries to low per capita incomes and undernutrition for years to come.

The purpose of this paper is to test empirically the null hypothesis that the population growth rate is not influenced by the per capita income growth rate. This hypothesis has been addressed in the past on both deductive and empirical grounds. Microeconomic theoretical analysis suggests that higher family income results in higher fertility rates (Becker). Some empirical evidence supports this conclusion (Adelman). However, other empirical studies report negative income elasticities of fertility (Ben-Porath, for example).

Theoretical Model

The Cobb-Douglas production function has been widely used to relate national output to labour and capital resources. Comparisons between developed and developing countries suggest somewhat comparable elasticities of production and of factor shares (Thirlwall), hence providing empirical support for this functional form for a global assessment.

Defining Y as national output, K as human and material capital, L as labour and α , β , and γ as constants, then:

$$(1) \quad Y = \alpha K^{\beta} L^{\gamma}; \text{ and}$$

$$(2) \quad y = Y/L = \alpha K^{\beta} L^{\gamma-1}.$$

Designating proportional rates of growth in neutral technology change (NTC) as $\dot{\alpha}$, in capital as \dot{K} , and in labour as \dot{L} , the proportional rate of change in output per unit of labour is:

$$(3) \quad \dot{y} = \dot{\alpha} + \beta \dot{K} + (\gamma - 1)\dot{L}.$$

It is apparent from (3) that, in the absence of induced NTC or induced capital formation, an increase in labour supply will reduce output per unit of labour if $0 < \gamma < 1$ with $\dot{K} = 0$. Estimated values of γ are frequently near 0.75, although values ranging from 0.6 to 0.9 are sometimes found. If $\gamma = 0.75$, a 1 percent increase in labour force (or population if labour is a constant proportion of population) will reduce per capita output by 0.25 percent.

If constant returns to scale prevail, in the absence of labour induced changes in \dot{K} and NTC, (3) can be expressed as:

$$(4) \quad \dot{y} = \beta(\dot{K} - \dot{L}).$$

Output per worker grows if labour grows at a slower rate than capital. If $\beta = 0.25$ and labour is constant, then output per labourer will grow at 1 percent per year if capital grows at 4 percent per year.

If growth in y sufficiently reduces \dot{L} , it is possible that y can be stabilized or

even raised without increases in K . Or the impact of \dot{K} on \dot{y} can be enhanced if an increase in \dot{y} induces a reduction in \dot{L} . The parameter central to this analysis is the behavioural response of labour supply to per capita income growth as defined by:

$$(5) \quad \delta = (dL/dy)(y/L); \text{ or}$$

$$(6) \quad \dot{L} = \delta \dot{y}.$$

With no induced NTC and constant returns to scale, substituting (6) into (3) gives:

$$(7) \quad \dot{y} = [\beta/(1 + \beta\delta)]\dot{K}, \text{ or}$$

$$(8) \quad \dot{y} = \dot{K}/[(1/\beta) + \delta].$$

If $\beta = 0.25$, then \dot{y} will change at the same rate as \dot{K} if $\delta = -3$. But for rapid economic progress, it is desirable for \dot{y} to be highly responsive to increments in \dot{K} . As the denominator $(1/\beta) + \delta$ approaches zero, small increments in \dot{K} induce large changes in growth in per capita income \dot{y} . If $\beta = 0.25$, additional capital brings large changes in \dot{y} as δ approaches -4 . In the absence of gains in \dot{K} or α induced by \dot{L} , most rapid rates of growth in income per unit of labour come from values of δ slightly larger than $1/\beta$. Whether δ is consistent with such numbers is an empirical question addressed in the remainder of this paper.

Econometric Models of Population Growth

Table 1 contains two econometric models used to estimate δ . The assumption in the cross sectional model is that the labour force is proportional to population in the long run so that L can be replaced by population. Because population growth rate (PGR) is crude birth rate (CBR) minus crude death rate (CDR), the latter two variables are used to measure PGR in order to obtain information on its components. In model I, CBR is a function of life expectancy and CDR, and is used to account for the social security provided by surviving children as well as the stage in the demographic transition. These variables are determined jointly. Other variables in the CBR equation are per capita income growth rate \dot{y} , family planning, literacy rate, religion, and proportion of rural population. In model II, CBR is simultaneously determined only with life expectancy and is exogenously influenced by family planning programmes, rural-urban income differences, and by the interaction of current per capita income and the historical rate of growth in per capita income.

Crude death rate in model I is a function of endogenously determined life expectancy and per capita income, and exogenously determined past growth rates in per capita income and number of persons per physician. In model II, CDR is a function of endogenously determined life expectancy, and of exogenously determined per capita income, family planning programmes, number of persons per physician (a proxy for health care), and the interaction of current per capita income and the historical rate of growth in per capita income.

Empirical Results

Statistical estimates were computed for each equation in table 1 by ordinary least squares (OLS), two stage least squares (2SLS), and three stage least squares (3SLS). Observations are for 64 countries ranging from low income to high income for which complete data were available.

Results of OLS estimates for CBR and CDR equations in model I are shown below:

$$(9) \quad \text{CBR} = 59.29 - .3097X_3 - .0006443X_4 - .2813X_5 - 9.701X_9 \\
\begin{array}{ccccc}
(.01) & (.03) & (.09) & (.45) & (.01) \\
[-.29] & & [-.12] & [-.037] & [-.33]
\end{array} \\
- 7.959X_{10} + 1.912X_{12} + 3.785X_{13} \\
\begin{array}{ccc}
(.08) & (.09) & (.32) \\
[-.20] & [.080] & [.073]
\end{array}$$

$$[R^2 = .92]$$

$$(10) \quad \text{CDR} = 40.41 - .5026X_3 + .001062X_4 - .3005X_5 + .07905X_{11} \\
\begin{array}{ccccc}
(.01) & (.01) & (.01) & (.70) & (.01) \\
[-1.04] & & [.43] & [-.087] & [.18]
\end{array}$$

$$[R^2 = .91]$$

All coefficients display theoretically admissible signs. Based on the standardized regression coefficients in brackets, life expectancy and presence of family planning programmes most strongly influence CBR. Probabilities of a larger t (in parenthesis) are reported for a two tailed distribution. Given the expected negative sign on the coefficient of the literacy rate and the expected positive sign on the coefficient of the religion variable, these coefficients can be viewed as significant by a one tailed t -test.

Crude death rate is strongly related to life expectancy and, to a lesser extent, to per capita income based on standardized regression coefficients. But better health care as evidenced by fewer persons per physician significantly reduces CDR.

Although the coefficient of \dot{y} (variable X_5) is not significantly different from zero in equations for either CBR or CDR, we shall use the estimated coefficient $-0.02813 + 0.03005 = 0.00192$ as the most likely value of δ . (Because CBR and CDR are in number per 1,000 persons, the value is converted to percent by moving the decimal one place to the left.) One percentage point increase in per capita income growth increases population growth by only 0.00192 percentage points. Clearly no basis exists to reject the null hypothesis of $\delta = 0$.

It is possible that \dot{y} impacts on PGR through intervening variables such as life expectancy, but the coefficient of \dot{y} in the life expectancy equation was small and significantly different from zero only at the 85 percent level. Statistical results of 2SLS and 3SLS are not shown because they gave even less evidence that δ differed from zero.

In searching for alternate functional forms that would reveal a greater absolute value of δ , model II was estimated by the same three statistical procedures as used to estimate model I. We postulate that the impact of the per capita income growth rate on the population growth rate is a function of the current level of per capita income. Furthermore, fewer variables were specified as endogenous, to simplify the model. (See table 2.)

All coefficients display theoretically admissible signs as can be seen below:

$$(11) \quad \text{CBR} = 68.34 - .5070X_3 - 9.425X_9 + .0007999X_{14} - .0005169X_{15} \\
\begin{array}{ccccc}
(.01) & (.01) & (.01) & (.01) & (.01) \\
[-.4742] & & [-.3251] & [.2139] & [-.3823]
\end{array} \\
[R^2 = .91]$$

$$(12) \quad \text{CDR} = 40.74 - .5229X_3 + .00165X_4 + .08202X_{11} - .0001590X_{15} \\
\begin{array}{ccccc}
(.01) & (.01) & (.01) & (.01) & (.05) \\
[-1.0818] & & [.6731] & [.1808] & [-.2600]
\end{array}$$

$$[R^2 = .91]$$

Table 1. Econometric models of population growth

Variable, Units and Date	Model	Variables X_i in Model ^a														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15 (4x5)
1. Crude birth rate (No./1,000 pop., 1975)	I II			E	E	X				X	X		X	X		
2. Crude death rate (No./1,000 pop., 1975)	I II			E	E	X				X					X	X
3. Life expectancy (Years, 1975)	I II		E	E		E	X				X	X				X
4. Per capita GNP (U. S. dollars, 1976)	I		E	E				E	E					X	X	
5. Growth rate, GNP per capita (%/yr., 1960-76)																
6. Investment per labourer (U.S. \$/worker, 1976)	I			E	E			E	E							
7. Proportion of GDP from agriculture (1976)	I							E	E					X	X	
8. Proportion of GNP invested (1976)	I				E			E	E							
9. Family planning (1=programme; zero other, 1976)																
10. Literacy rate (Proportion lit., 1974)																
11. No. of persons per physician (1,000, 1974)																
12. Religion (1=Catholic, zero other, 1975)																
13. Proportion of population rural (1974)																
14. Rural-urban income diff. (U. S. dollars, 1976)																

^aE = endogenous, X = exogenous.Source of data: World Bank. World Development Report, 1978. Oxford: Oxford University Press, 1978.

Table 2. Two-stage least squares (2SLS) and three-stage least squares (3SLS) estimated from Model II.

D. V.	Item	Int.	3	4	9	11	14	15
CBR	2SLS	Reg. Coeff.	70.77	-.5565		-8.651	.00074	-.00048
		Prob. > t	(<.01)	(<.01)		(<.01)	(<.02)	(<.01)
	3SLS	Reg. Coeff.	70.42	-.5481		-9.031	.0072	-.00046
		Prob. > t	(<.01)	(<.01)		(<.01)	(<.02)	(<.01)
CDR	2SLS	Reg. Coeff.	39.80	-.5058	.0015	.0884		-.00015
		Prob. > t	(<.01)	(<.01)	(<.01)	(<.01)		(<.06)
	3SLS	Reg. Coeff.	39.56	-.5020	.0015	.0921		-.00015
		Prob. > t	(<.01)	(<.01)	(<.01)	(<.01)		(<.06)

See Table 1 for definitions of variables, source of data and form of complete model. DV: Dependent variable, Int: intercept.

The coefficient of the income interaction variable $X_{15} = X_4X_5$ is highly significant for each estimation procedure in the CBR equation, and the standardized regression coefficient is -0.4 in the OLS form, above. The coefficient of the income interaction (4 x 5) was highly insignificant in the life expectancy equation of model II, and hence gave no evidence that PGR was influenced by income growth through the intervening life expectancy variable.

Holding per capita income at the sample mean of \$1,842, the estimated value of δ is -0.066. With per capita income set is \$500, δ is -0.018, and for y set at \$100, δ is -0.000344. Results from the 2SLS and 3SLS estimations were consistent with these values. Estimates of δ were also near zero for equations computed separately for high income and low income countries using models I and II.

We chose to measure δ from the 1960-76 growth rate of income per capita (variable X_5) because time is required to adjust birth and death rates to per capita income. However, alternative estimates of δ were computed from current per capita income (variable X_4). These estimates of δ were found to be small and approach zero for low income countries.

Conclusions

Estimated values of δ are too small to justify rejection of the null hypothesis that $\delta = 0$. The results hold out little hope that increasing per capita income alone will reduce the rate of population growth in developing nations or result in large coefficients for K in equation (9). On the other hand, the results suggest that family planning programmes can significantly reduce population growth rates.

Population growth rates in many countries have declined in recent years. The decline characterizes countries with high and low per capita incomes and low growth rates in per capita income. Thus, the decline seems to be associated not with changes in income but with shifting attitudes toward ideal family size.

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OPENER'S REMARKS--Jesus C. Santa Iglesia

The finding that income growth does not affect population growth is difficult to dispute. The theoretical framework and the econometric models are widely accepted and the statistical analysis is sound. But there are other dimensions which the present analysis may not have considered.

A country by country analysis may bring up different results. A high income level effect in one country may equate to a low income level in another country. Aggregating the two countries will therefore not capture the differential effects. This point may also be expanded within a country. Certain threshold

levels of income may have to be reached before the effects of income growth on population growth may be felt.

Intervening factors between income and population growth may have to be examined in more depth. Effects of income growth on population growth may have to come through increased education, which in turn results in different attitudes, including an increased appreciation for (and circumstantial delay of) marriage, increased awareness of ways of obtaining sexual gratification that do not result in conception, and so on. The effects of income growth in a particular period may be seen, then, only at a later period, hence cross sectional analysis may not be an appropriate method of estimating them.

RAPPORTEUR'S REPORT--Kanok Khatikarn

The model should be disaggregated by income level in developing countries. However, the author indicated that the model cannot be used to do country by country analysis because of problems with the low degrees of freedom.

Crude birth rates and death rates should be adjusted for the age structure within each country, but the model was found to exhibit more multicollinearity error by including manipulated data on age structure.

It was suggested that the model should have employed income distribution data such as those available from the World Bank, but the author indicated that the World Bank data are not reliable.