Demographic and Other Determinants of Economic Growth

by

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DEMOGRAPHIC AND OTHER DETERMINANTS OF ECONOMIC GROWTH

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This paper describes an econometric investigation of the effects of population growth on the growth of output. A structural model yields a reduced-form equation in which output growth is a function of exogenous variables both demographic and nondemographic. This equation is estimated from data on 142 recent six-year growth periods in 85 countries at all levels of per capita income. Higher fertility is found to lower output growth in the short run and raise it in the long run (after twelve years). Export orientation and currency depreciation are not found to have the strong stimulative effects commonly reported.

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I. INTRODUCTION*

What is the effect of population growth on the growth of output? The question is of obvious practical importance, but no clear consensus has emerged from the answers that economists have provided. Most of these answers have been based on one or other of three approaches. First, there is the approach of specifying a simple macroeconomic model and obtaining a direct analytical solution for the relationship between population growth and output growth. Models of the "steady-state" type illustrate this approach, and have generally yielded antinatalist results (e.g., Solow, 1970). Second, more complex models are specified, too complex to permit analytical solutions, and simulation techniques are employed to show the effects of alternative population growth rates on output growth. This approach has yielded results which are sometimes antinatalist (Coale and Hoover, 1958) and sometimes pronatalist (Simon, 1976). Third, econometric studies have examined historical correlations between population growth and output growth, using either cross-sectional or time-series techniques. Pronatalists have found some econometric support for their view that population increases lead to more than proportionate increases in output, but contrary results have also been found.

This paper attempts some more econometric analysis of the relationship between population growth and output growth. The attempt is worth making because the existing literature in this area is unsatisfactory in several respects:

1. Many of the studies do no more than report simple correlations between

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the two variables.[1] It seems clear that the growth of output is determined by many factors besides population growth, and that these factors ought to be specifically included in the analysis in order to lessen the chance that the correlation observed between the two variables of primary interest is spurious.

2. Some studies have estimated multivariate equations in which output growth is a function of both demographic and nondemographic variables, but these equations are not always derived from a coherent underlying model of economic growth. The explanatory variables are too often selected *ad hoc*, and the numerical results are accordingly difficult to interpret.

3. The population growth variables employed in the econometric studies usually fail to distinguish between growth due to natural increase and growth due to immigration, whereas it seems clear that these two phenomena may have very different effects on the growth of output. This problem mars the studies by Agarwala (1983), Faini *et al*. (1984), and Landau (1986). It is avoided by Plane (1988), who uses a natural increase variable in his output growth equations.

4. The studies fail to recognize the long-run effect of population growth on the economy, restricting themselves to the effects which population growth occurring within a certain period has on output within the same period.

This paper attempts to avoid these shortcomings by first specifying a general structural model of economic growth in which separate roles are played by fertility variables (lagged and unlagged), net immigration, and nondemographic

[1]For a review of the bivariate correlations, see Barlow (1986).

factors. From this structural model a reduced-form equation is obtained in which output growth is expressed as a function of exogenous variables both demographic and nondemographic. This equation is then estimated with pooled cross-sectional and time-series international data.

The data employed in this estimation relate to 142 recent six-year periods of output growth observed in 85 countries covering the entire range of per capita income. Higher fertility is found to lower output growth in the short run and raise it in the long run (after twelve years). The net result of these two conflicting effects is that higher fertility lowers output per capita, at least within the 24-year horizon considered. Net immigration contributes positively to output growth.

Among nondemographic variables assumed exogenous, clearcut contributions to output growth are made by increases in mining production and decreases in political violence. Output growth is negatively related to per capita output, at least among countries with per capita output over $1,500. Variables which show inconsistent relationships to output growth, being significant in some variants of the reduced-form model and nonsignificant in others, include the improvement in the terms of trade and the increase in capital inflow between the beginning and end of the growth period. Variables with little apparent explanatory power include the total amount of capital inflow during the growth period, the US growth rate, export orientation, the change in the real exchange rate, military spending, the lagged increase in educational spending, health improvements as indicated by increases in life expectancy at birth, and the percentage of the population who are Moslems. The rate of taxation appears to have a positive influence on output growth, although this result is based on a relatively small subgroup of countries.

II. A GENERAL MODEL OF ECONOMIC GROWTH

In this section a reduced-form growth equation is derived from a structural model of the macroeconomy, following the "growth components" logic exemplified by Hagen and Hawrylyshyn (1969). Suppose that actual output Y in year t is a fraction c of potential output Y*:

$$Y_t = c_t Y^*_t \qquad (1)$$

The annual growth rate of actual output can then be expressed as follows:

$$\dot{Y} = \dot{c} + \dot{Y}^* + \dot{c}\dot{Y}^* \qquad (2)$$

where the superscript (•) represents the variable's rate of increase [e.g. $\dot{Y}$ = (dY/dt)/Y]. Suppose next a general production function expressing the relation between potential output and four input terms: natural resources (R), quality-weighted labor (L), quality-weighted capital (K), and an index of allocative efficiency (A)[a]:

$$Y^*_t = f_1\ (R_t,\ L_t,\ K_t,\ A_t) \qquad (3)$$

Differentiation of the production function with respect to time yields the following:

$$\dot{Y}^* = r_R\dot{R} + r_L\dot{L} + r_K\dot{K} + r_A\dot{A} \qquad (4)$$

where r_j is the elasticity of potential output with respect to input j. In order to arrive at an estimatable reduced-form equation for the growth rate of actual output, each of the eight terms on the right-hand side of this equation must be expressed as a function of measurable exogenous predictors. To simplify this task, predictors will be sought for the four input growth rates but not

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[a]Quality-weighted labor (L) can be expressed as the quantity of standardized labor inputs (L') multiplied by an index of labor quality (ql), the latter reflecting the skills, motivation, and health of the labor force. Similarly, quality-weighted capital (K) is the quantity of standardized capital (K') multiplied by an index of capital quality (qk), the latter reflecting the state of embodied technology. The index of allocative efficiency (A) reflects the nature of the resource allocation choices made in the economy, both "what" to produce and "how" to produce it.

for the four output-elasticities. In line with Equation (2), it is also necessary to find predictors for the growth rate of the capacity utilization variable (c). Hence there are five areas where exogenous predictors must be sought, and these are dealt with in turn.

Natural Resource Growth

A measurable variable which is likely to be closely related to the growth rate of utilized natural resources, and which can reasonably be assumed exogenous, is the ratio between the growth of mining output at constant prices (dM) and the initial level of actual output, or

$$\dot{R} = f_2 \underset{+}{(dM/Y)} \qquad (5)$$

The sign under the explanatory variable indicates the hypothesized direction of its effect *ceteris paribus* on the dependent variable (and on the growth rate of output).

The basis for assuming mining output to be exogenous is that its major determinants are such factors as discoveries of new deposits, exhaustion of old deposits, production decisions made by the multinational companies controlling many of the deposits in an enclave setting, and movements in world commodity prices. None of these factors is much affected by the current growth of GDP in the country in question. On the other hand, it is desirable to see whether the final results are sensitive to this assumption of mining exogeneity, and so in part of the analysis, (dM/Y) is replaced by an instrumental variable [(dM/Y)@]:

$$\dot{R} = f_{2a} \underset{+}{[(dM/Y)@]} \qquad (5a)$$

Here and elsewhere in the growth model, the "@" symbol indicates that the variable in question appears in the regression analysis with estimated rather than actual values, the estimation being based on variables which are predetermined or for other good reasons judged to be independent of current output growth. A total of nine instrumental variables, including the one for mining growth, appear in the reduced-form equation. The regressions used for estimating them are shown in the Appendix (Table A.1).

<u>Labor Growth</u>

For the growth rate of the quality-weighted labor force, the following exogenous determinants are proposed: the instrumentalized current net birth rate (births minus infant deaths as a percentage of the population, N/P), since child bearing and child care may reduce female participation in the labor force; the net birth rate in earlier periods, allowing a lag between the arrival of newborns and their eventual entry into the labor force; the instrumentalized rate of net immigration (I/P) in the current period; instrumentalized military spending (E) during the current period in relation to the initial level of output; the growth rate of lagged educational expenditures ($\dot{Q}$); and the improvement in health conditions, as proxied by the (instrumentalized) increase in life expectancy at birth ($\dot{H}$).[3] That is,

$$\dot{L} = f_3 \, [\underset{-}{(N/P)@}, \; \underset{+}{(N/P)_{-2}}, \; \underset{+}{(N/P)_{-3}}, \; \underset{+}{(I/P)@}, \; \underset{+}{(E/Y)@}, \; \underset{+}{\dot{Q}}, \; \underset{+}{\dot{H}@} \,] \qquad (6)$$

The lags of two and three periods selected for the net birth rate variable reflect the six-year length of the growth period used in the regression analysis, and mean that labor force growth is affected positively by fertility

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[3]This formulation of labor force growth ignores (a) fertility and infant mortality more than 24 years before the end of the growth period and (b) past mortality at ages over twelve months. The first factor is likely to be closely correlated with $(N/P)_{-3}$, while the second probably accounts for a relatively small part of the variance in labor force growth.

levels prevailing between 24 and 12 years prior to the end of the growth period.[4] (Data do not permit lags of more than three periods.)

Instrumental variables are used for the current net birth rate, the net immigration rate, and military spending because it can be plausibly argued that each of these three factors is influenced by the current growth of output. In effect, it is a matter of indifference whether the current net birth rate is represented in the regression analysis by itself or by its instrument, since the correlation coefficient between the two of them is 0.996. Net births in, say, 1978-83 can be very precisely estimated on the basis of net births in 1977 and 1966-71, plus a few other exogenous variables. (See Table A.1.) This result, incidentally, supports the contention frequently made by demographers that fertility is essentially unaffected by the current growth of output.[5]

The sign under the military spending variable represents the Benoit (1978) hypothesis that such spending raises the technical skills of military personnel, who then use these skills in their subsequent civilian careers.

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[4]In this analysis the net birth rate is preferred to the crude birth rate or other conventional measures of fertility on the grounds that infants dying before the age of twelve months have relatively small effects on the economy and should therefore be deducted from the total number of births. Similar reasoning could justify the subtraction of "child deaths" occurring between the ages of one and five. Since child deaths are in most cases significantly less numerous than infant deaths, an adjustment for child deaths would not have much effect on the statistical results, and has not been attempted here.

[5]See, for example, Blanchet (1988, p.88): "It is usual to try to explain mortality rates or birth rates by the various levels of income observed in LDC's, but it is generally considered that taking into account the current variations in these levels cannot add much to this explanation" (emphasis added).

<u>Capital Growth</u>

The growth of quality-weighted capital is a function of total domestic saving during the whole growth period in relation to the initial level of output (S/Y), total foreign saving (or capital inflow) during the growth period in relation to the initial level of output (F/Y), and the rate of increase in the index of embodied technology between the beginning and end of the growth period:

$$\dot{K} = f_4 \; [\; \underset{+}{S/Y}, \; \underset{+}{(F/Y)@}, \; \underset{+}{\dot{qk}} \;] \tag{7}$$

The technology term is not measurable and is therefore represented by its exogenous determinants, which are assumed to be the initial level of per capita output, the current net birth rate, and the rate of capital inflow:

$$\dot{qk} = f_5 \; [\; \underset{?}{Y/P}, \; \underset{+}{(N/P)@}, \; \underset{+}{(F/Y)@} \;] \tag{8}$$

The query under the per capita output variable reflects the fact that reasonable hypotheses can be advanced for both positive and negative relationships between per capita output and the subsequent improvement in technology.[6] Richer countries usually devote a larger proportion of their resources to R&D, but poorer countries are able to exploit an extensive backlog

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[6]One reader of this paper has pointed out that Y/P may not be independent of $\dot{Y}$ if a given country's growth rates are correlated over time (that is, if $\dot{Y}$ is correlated with $\dot{Y}_{-1}$). In that event, the fact that Y/P is affected by $\dot{Y}_{-1}$ (this year's level is affected by last period's growth) may suffice to produce a significant correlation between Y/P and $\dot{Y}$. For the growth cases analyzed in the present study, the correlation coefficient (R) between $\dot{Y}$ and $\dot{Y}_{-1}$ is found to be 0.40, which is significantly different from zero at the 95 per cent confidence level. However, the correlation coefficient between Y/P and $\dot{Y}_{-1}$ is only 0.11, which is not significantly different from zero. Hence the assumption that Y/P is independent of $\dot{Y}$ in Equation (9) and elsewhere in the growth model seems safe. (These coefficients relate to 141 growth cases and exclude the two US observations and the highly anomalous case of Libya 1968-74, where the lagged six-year GDP growth rate was 341 per cent. If the Libyan case is included, the coefficients described above are 0.21 and 0.07 respectively.)

of unused technological improvements. As for the current net birth rate variable, its hypothesized sign reflects the Boserup (1981) view that a high rate of population growth creates population density pressures which stimulate technological innovation. (The same view would also justify the use of lagged net birth rates in this equation.) The rationale for the capital inflow term is that such inflows are often associated with imports of investment goods, which are assumed to possess relatively advanced technology.

The first determinant of capital growth, the domestic saving rate, is measurable, but will nonetheless be represented in the reduced form by its own determinants, and this for two reasons. First, there are grounds for believing that saving data are of above-average unreliability.[7] Second, it is possible that saving rates are significantly affected by the demographic variables which are of primary analytical interest. The following saving function is proposed, in which all explanatory variables except the first are exogenous:

$$S/Y = f_6 \left[\underset{+}{\dot{Y}},\ \underset{-}{(N/P)@},\ \underset{-}{(N/P)-1},\ \underset{?}{(E/Y)@},\ \underset{?}{Y/P},\ \underset{?}{(T/Y)@},\ \underset{+}{\dot{B}},\ \underset{-}{\bar{D}},\ \underset{-}{Z},\ \underset{-}{(F/Y)@} \right] \qquad (9)$$

Higher rates of output growth ($\dot{Y}$) induce higher rates of domestic saving if the permanent income hypothesis is true. Higher net birth rates in the current and immediately past six-year periods are expected to reduce saving by increasing the burden of dependency. Military spending (E/Y) can either raise or lower public saving, depending on whether the spending is devoted to investment or not.[8] Given the distribution of income, a higher initial level of per capita output (Y/P) implies a higher saving rate if the aggregate consumption function

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[7]See Gersovitz (1988), pp. 413-15.

[8]This is because public saving is defined as the public sector's revenues minus its noninvestment spending.

is typical; however, higher levels of per capita output could over some ranges be associated with increasing equality of income distribution and hence perhaps with lower saving rates. Taxation (T/Y) can either raise or lower saving, depending on relative propensities to save in the private and public sectors.[9] An improvement in the terms of trade index ($\dot{B}$) raises the real income associated with a given volume of domestic output, and hence may raise domestic saving. Higher levels of political instability, as measured by an indicator like the average annual per capita number of deaths due to political violence during the growth period ($\bar{D}$), may depress saving.[10] If a high percentage of the population is Moslem (Z), domestic saving rates may be low, because of certain attitudes and practices associated with Islam (e.g. fatalism, almsgiving, the prohibition of interest). Capital inflows (F/Y) may partially substitute for domestic saving.

Allocative Efficiency Growth

For the rate of increase in the index of allocative efficiency (A), five exogenous determinants are suggested:

$$\dot{A} = f_7 \; [\underset{+}{(N/P)@}, \; \underset{-}{dD}, \; \underset{-}{d(T/Y)@}, \; \underset{+}{J}, \; \underset{-}{\dot{X}} \;] \qquad (10)$$

The sign on the current net birth rate (N/P) reflects another aspect of the Boserup hypothesis about fertility and technology: this time it is disembodied rather than embodied technology which will be stimulated by high fertility. Increases in political instability during the growth period (dD) or in the tax rate [d(T/Y)] may reduce allocative efficiency. Countries starting the growth

[9] A tax ratio variable is found by Landau (1986) to have a negative effect on output growth.

[10] Political instability variables are found by Wheeler (1984) and Timmerman and Scholing (1986) to have negative effects on output growth.

period with a high degree of export orientation (J) may be led by competitive pressures to achieve higher rates of allocative improvement.[11] Government interventions during the growth period which distort prices may lead to misallocations. One recent empirical study of the effects of price distortion on growth identifies seven different types of distortion, and finds the most serious to be currency overvaluation (Agarwala, 1983). The rate of increase in the real exchange rate ($\dot{X}$) has therefore been included here as an exogenous determinant of allocative efficiency.

Capacity Utilization Term

The rate of capacity utilization is assumed to be lowered between the beginning and end of a six-year growth period by a deterioration in the terms of trade ($\dot{B}$) or by a decline in foreign capital inflow within the period [d(F/Y)], both of which cause import curtailments and consequent production stoppages; by a reduction in the current net birth rate (N/P), which reduces aggregate demand and hence has Keynesian effects on output; by increasing political instability (dD); and by a worsening of world economic conditions, which reduces demand for the country's exports. World economic conditions can

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[11] Following the methodology of Balassa (1985) and others, export orientation is defined here as the difference in the base year of the growth period between the actual ratio of exports to GDP and the ratio predicted on the basis of nonpolicy variables like population size and mineral endowment. The least-squares regression equation used here for predicting exports as a percentage of GDP (EXP/Y) is as follows:

$$EXP/Y = 27.5 + \underset{(0.0422)}{0.1534}(Y/P) + \underset{(0.1176)}{0.4646}(M/Y) - \underset{(0.0553)}{0.2376}P + \underset{(0.0001)}{0.0003}P^2$$

where Y/P is per capita GDP in hundreds of US dollars, M/Y is mining output as a percentage of GDP, and P is population in millions. The data are for 1980 and relate to the 85 countries listed in Table A.2 (excluding the US). Numbers in parentheses are standard errors, and the R^2 is 0.40.

be proxied by the growth rate of real GDP in the United States ($\dot{U}$). These hypotheses are represented by the following equation:

$$\dot{c} = f_8 \, [\, \underset{+}{\dot{B}},\ \underset{+}{d(F/Y)@},\ \underset{+}{(N/P)@},\ \underset{-}{dD},\ \underset{+}{\dot{U}} \,] \qquad (11)$$

. . . .

For a full understanding of how output growth rates are determined, it would be necessary to estimate all eleven equations of this system. This is not possible, because several of the variables are in practice unobservable -- for example, the capacity utilization rate (c), natural resources (R), quality-weighted labor (L), and quality-weighted capital (K). However, it is possible to derive an estimatable reduced-form equation from the model, with the object of revealing the net effect of each exogenous variable on output growth. (The exogenous variables in this context include the nine instrumental variables introduced above.) The reduced form yielded by the twelve equations is as follows:

$$\begin{aligned} \dot{Y} = f_9 \, [\, & \underset{+}{(dM/Y)@},\ \underset{?}{Y/P},\ \underset{?}{(N/P)@},\ \underset{-}{(N/P)\text{-}1},\ \underset{+}{(N/P)\text{-}2},\ \underset{+}{(N/P)\text{-}3}, \qquad (12) \\ & \underset{+}{(I/P)@},\ \underset{?}{(E/Y)@},\ \underset{+}{\dot{Q}},\ \underset{+}{\dot{H}@},\ \underset{?}{(F/Y)@},\ \underset{?}{(T/Y)@},\ \underset{+}{\dot{B}},\ \underset{-}{\bar{D}},\ \underset{-}{Z}, \\ & \underset{-}{dD},\ \underset{-}{d(T/Y)@},\ \underset{+}{J},\ \underset{-}{\dot{X}},\ \underset{+}{d(F/Y)@},\ \underset{+}{\dot{U}} \,] \end{aligned}$$

Since Y/P, N/P, and F/Y each have hypothesized partial derivatives with respect to $\dot{Y}$ which possess different signs in different structural equations, their derivatives in the reduced form are of indeterminate sign <u>a priori</u>.

III. DATA

In obtaining country-level data for the estimation of Equation (12), we first exclude for convenience' sake the large number of mini-states, defined here as those with a population under two millions in 1984. This leaves 119 countries available for the analysis. For 33 of these countries, data are available for fewer than sixteen of the twenty-one explanatory variables in Equation (12), and these countries (mostly socialist) are excluded from the subsequent analysis. Among the remaining 86 countries, there are several where no data exist for one or other of five explanatory variables: the two political violence variables, the two tax variables, and the lagged education expenditure variable.

This problem of missing data is handled in the usual way by specifying alternative models. Five basic models are used:[12]

Model I: 16 common explanatory variables only (85 countries)

Model II: 16 common variables plus lagged education expenditure (60 countries)

Model III: 16 common variables plus political violence variables (70 countries)

Model IV: 16 common variables plus lagged education expenditure and political violence variables (46 countries)

Model V: 16 common variables plus tax variables (35 countries)

To increase further the number of observations for these models, each country is represented by two nonoverlapping growth periods where possible. A growth period of six years is chosen for the analysis. (A longer period would reduce significantly the number of observations in view of data limitations; a shorter period would increase the relative importance of unmeasured short-run factors like climatic fluctuations.) The choice of a particular six-year period

[12]Although possessing data for all twenty-one explanatory variables, the US is excluded from the analyses with Models I-V, since its own growth rate is an explanatory variable in those models. However, it is included in the analyses with Models VI-VIII, which do not contain the US growth rate as an explanatory variable.

for a particular country is determined by a random process. For example, if data on a country are only available for 1971-79, three six-year periods are possible (1971-77, 1972-78, and 1973-79), and the choice between these three is made randomly. As a result of these procedures, 57 of the 85 countries in Model I are represented by two six-year growth periods each, and the remainder by one period each, for a total of 142 cases. The cases are listed in the Appendix (Table A.2). The observations available for Models II, III, IV, and V are similarly augmented. The growth periods range from 1968-74 to 1977-83. Earlier periods are ruled out because of the long 18-year lag required for one of the net birth rate variables.

IV. EMPIRICAL RESULTS

Least-squares estimates of the reduced-form equation yielded by the growth model -- or at least estimates of the truncated versions of that equation represented by Models I through V -- are shown in Table 1. The explanatory variables are listed under three broad categories -- demographic, external environment, and socio-political. The results obtained for the demographic variables are considered first.

Fertility and the Growth of Output

Estimation of Model I with no restrictions on the coefficients of the independent variables yields the results shown in Column (1) of Table 1. Only one of the four net birth rate variables has a coefficient which is statistically significant at the 95 per cent confidence level. This situation often arises with multiple lags, and is usually due to the high degree of multicolinearity existing between the lagged variables.

Table 1

DETERMINANTS OF ECONOMIC GROWTH: REGRESSION RESULTS

Dependent variable: percentage change in real gross domestic product over six-year period ($\dot{Y}$): observations for periods ranging from 1968-74 to 1977-83 in countries with 1984 population over two million

Independent variables:		2SLS regression coefficients (standard errors in parentheses): MODEL I — No restrictions on coefficients	MODEL I — Restrictions on coefficients of net birth rate variables: Coefficients fitting quadratic lag function	MODEL I — Restrictions on coefficients of net birth rate variables: Coefficients fitting linear lag function — All cases	MODEL I — Linear lag function: All cases (instrumental variable for mining growth)	MODEL I — Linear lag function: All cases excluding 8 outliers	MODEL I — Linear lag function: Cases with per capita GDP>$1,500	MODEL I — Linear lag function: Cases with per capita GDP<$1,500	MODEL II — All cases#
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DEMOGRAPHIC FACTORS									
(N/P)●	net birth rate, unlagged	-5.839** (2.392)	-4.232	-2.242	-2.463	-2.350	-1.835	-2.461	-1.995
$(N/P)_{-1}$	net birth rate, lagged 1 period	5.027 (4.751)	1.339	-0.696	-0.773	-0.791	-0.461	-0.846	-0.631
$(N/P)_{-2}$	net birth rate, lagged 2 periods	-1.075 (5.342)	3.078	0.850	0.917	0.768	0.913	0.769	0.733
$(N/P)_{-3}$	net birth rate, lagged 3 periods	2.418 (2.052)	0.985	2.396	2.607	2.327	2.287	2.384	2.097
v_0	coefficients in lag function for net birth rate	...	-4.232** (1.325)	-2.242** (0.391)	-2.463** (0.473)	-2.350** (0.404)	-1.835** (0.507)	-2.461* (1.227)	-1.995** (0.543)
v_1		...	7.487* (3.791)	1.546** (0.276)	1.690** (0.356)	1.559** (0.286)	1.374** (0.353)	1.615 (0.997)	1.364** (0.362)
v_2		...	-1.916 (1.219)	...	...	...	...	...	...
DUM(I/P)●	immigration dummy	16.196** (7.414)	15.835** (7.391)	18.468** (7.240)	24.089** (8.361)	18.341** (7.693)	15.127* (8.135)	22.408 (17.670)	21.177** (9.773)
EXTERNAL ENVIRONMENT									
$\dot{B}$	terms of trade improvement	0.107 (0.128)	0.055 (0.110)	0.138 (0.097)	0.078 (0.158)	0.161 (0.100)	-0.029 (0.145)	0.272 (0.185)	0.144 (0.127)
(F/Y)●	rate of capital inflow	0.022 (0.115)	-0.025 (0.099)	0.055 (0.085)	0.113 (0.099)	0.073 (0.099)	-0.086 (0.118)	0.282 (0.231)	0.092 (0.159)
[d(F/Y)]●	increase in rate of capital inflow	1.357 (1.315)	0.846 (1.152)	1.647 (1.039)	1.639 (1.251)	1.862* (1.072)	-0.070 (1.632)	2.062 (2.026)	1.601 (1.299)
$\dot{U}$	GDP growth rate in USA	0.666 (0.721)	0.352 (0.608)	0.723 (0.562)	1.115 (0.722)	0.920 (0.570)	0.125 (0.688)	1.594 (1.152)	0.946 (0.709)
dM/Y	mining growth	0.813** (0.132)	0.814** (0.132)	0.831** (0.132)	...	1.219** (0.213)	0.749** (0.135)	1.598** (0.508)	1.006** (0.262)
(dM/Y)●	mining growth	...	...	...	1.861 (1.231)	...	...	...	...
SOCIO-POLITICAL FACTORS									
J	export orientation	0.133* (0.072)	0.138* (0.071)	0.108 (0.069)	0.033 (0.103)	0.097 (0.103)	0.148* (0.075)	-0.144 (0.219)	0.056 (0.124)
$\dot{X}$	increase in real exchange rate	-0.037 (0.062)	-0.053 (0.059)	-0.045 (0.059)	-0.036 (0.068)	-0.063 (0.064)	-0.016 (0.092)	-0.174 (0.108)	-0.114 (0.073)
(T/Y)●	tax rate	...	...	...	...	...	...	...	...
[d(T/Y)]●	increase in tax rate	...	...	...	...	...	...	...	...
(E/Y)●	military share of GDP	0.035 (0.075)	0.058 (0.069)	0.011 (0.062)	-0.056 (0.090)	0.047 (0.071)	0.095 (0.078)	-0.137 (0.142)	0.013 (0.166)
$\dot{Q}$	increase in lagged educ.exp.	...	...	...	...	...	...	...	0.082 (0.069)
$\dot{H}$●	increase in life expectancy	-3.252 (7.399)	-7.251 (5.490)	-1.431 (4.075)	0.782 (4.680)	-0.791 (4.386)	-6.127 (5.419)	-4.864 (9.059)	-3.404 (5.672)
Z	percent Moslem	0.089 (0.186)	0.175 (0.152)	0.032 (0.122)	-0.006 (0.139)	-0.009 (0.129)	0.163 (0.176)	-0.181 (0.237)	-0.001 (0.170)
$\bar{D}$	death rate from political viol.	...	...	...	...	...	...	...	...
dD	increase in death rate from political viol.	...	...	...	...	...	...	...	...
Y/P	GDP per capita	-0.195* (0.110)	-0.232** (0.100)	-0.159* (0.089)	-0.034 (0.178)	-0.208** (0.095)	-0.293** (0.113)	1.202 (0.927)	-0.260** (0.125)
Constant term		14.753	23.534	11.898	-8.830	13.507	33.723	-34.201	16.842
R^2		0.590	0.588	0.580	0.459	0.513	0.660	0.577	0.521
Number of cases		142	142	142	142	136	88	54	93
Number of countries		85	85	85	85	83	45	40	60

● = instrumental variable estimated from exogenous variables to avoid simultaneity
* = coefficient significant at 90 per cent confidence level
** = coefficient significant at 95 per cent confidence level
\# = the cases in Model 8 include no outliers

Table 1. continued

Independent Variables:		Regression coefficients (standard errors in parentheses)							
		2SLS and coefficients on net birth rate variables fitting linear lag function					OLS and no restrictions on coefficients		
		MODEL III		MODEL IV		MODEL V	MODEL VI	MODEL VII	MODEL VIII
		All cases	Excluding 6 outliers	All cases	Excluding 2 outliers				
		(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
DEMOGRAPHIC FACTORS									
(N/P)@	net birth rate, unlagged	-2.230	-2.193	-1.409	-1.427	-3.422	0.475* (0.247)	-0 330 (0.307)	-2.204** (0 490)
$(N/P)_{-1}$	net birth rate, lagged 1 period	-0.816	-0.813	-0.595	-0.635	-1.033	...	...	. .
$(N/P)_{-2}$	net birth rate, lagged 2 periods	0.598	0.567	0.219	0.157	1.356	..	..	. .
$(N/P)_{-3}$	net birth rate, lagged 3 periods	2.012	1.947	1.033	0.949	3.745	...	...	2.743** (0.583)
v_0	coefficients in lag function for net birth rate	-2.230** (0.461)	-2.193** (0.550)	-1.409* (0.707)	-1.427* (0.794)	-3 422** (0.721)	...	..	...
v_1		1.414** (0.348)	1.380** (0.394)	0.814 (0.512)	0.792 (0.588)	2.389** (0.488)	..	...	..
v_2		...	...	...	...	...	...	...	...
DUM(I/P)@	immigration dummy	2.713 (9.714)	4.428 (10.137)	-18.936 (18.796)	-18.363 (21.618)	-9.917 (16.066)	...	. .	..
EXTERNAL ENVIRONMENT									
$\dot{B}$	terms of trade improvement	0.276* (0.137)	0.276* (0.143)	0.204 (0.193)	0.208 (0.197)	0 587** (0.201)	...	...	.
F/Y	rate of capital inflow	0.215 (0.130)	0.168 (0.132)	0.199 (0.203)	0.172 (0.210)	0.460* (0.251)	...	...	...
[d(F/Y)]@	increase in rate of capital inflow	3.264** (1.578)	3.007* (1.621)	2.999 (2.398)	2.884 (2.539)	5.972** (2.433)	...	...	...
$\dot{U}$	GDP growth rate in USA	0.805 (0.770)	0.846 (0.791)	1.058 (1.010)	1.078 (1.022)	. 2.591** (0.986)	...	...	...
dM/Y	mining growth	0.658** (0.139)	0.808** (0.239)	0.851** (0.266)	0.873** (0.275)	1.508** (0.511)	...	...	...
(dM/Y)@	mining growth	...	..	...	...	...	...	..	...
SOCIO-POLITICAL FACTORS									
J	export orientation	0.070 (0.084)	0.021 (0 118)	-0 033 (0.140)	-0.063 (0.148)	-0.078 (0.112)	..	...	.
$\dot{X}$	increase in real exchange rate	0.262** (0.099)	0.194 (0.135)	0.320* (0.159)	0.327 (0.227)	0.375** (0.169)	...	...	..
(T/Y)@	tax rate	.	..	...	...	0.139** (0.062)	...	...	..
[d(T/Y)]@	increase in tax rate	...	...	...	...	1.524 (1.134)	..	..	.
(E/Y)@	military share of GDP	0.006 (0.090)	0.045 (0.094)	0.028 (0.239)	0 154 (0.268)	-0.281 (0.184)	...	...	..
$\dot{Q}$	increase in lagged educ.exp.	...	..	-0.071 ,0.104)	-0.090 (0.109)	...	..	..	..
$\dot{H}$@	increase in life expectancy	3.532 (5.686)	2.718 (5.798)	7.919 (9.020)	8.521 (10.453)	3.662 (7.662)	..	...	.
Z	percent Moslem	-0.248 (0.171)	-0.245 (0.174)	-0.317 (0.247)	-0.351 (0.288)	-0.465 (0.279)	...	..	...
$\bar{D}$	death rate from political viol.	-0.154** (0.056)	-0.419* (0.230)	-0.202** (^ 078)	-0.233 (0.281)	. .	...	..	..
dD	increase in death rate from political viol.	-0 104** (0.040)	-0.549 (0.345)	-0.080* (0.045)	-0.566 (0.467)	...	...	...	..
Y/P	GDP per capita	-0.186 (0.125)	-0.251* (0.142)	-0.063 (0.227)	-0.109 (0.281)	-0.060 (0.159)	...	-0.287** (0.071)	-0.189** (0 069)
Constant term		10.788	17.279	-0.611	2.385	-75.849	22.757	48.662	22.007
R^2		0.710	0.581	0.661	0.596	0 842	0 025	0.128	0.247
Number of cases		79	74	51	49	43	144	144	144
Number of countries		70	66	46	45	35	86	86	86

@ - instrumental variable estimated from exogenous variables to avoid simultaneity
* - coefficient significant at 90 per cent confidence level
** - coefficient significant at 95 per cent confidence level

Table 1, continued

Definitions of independent variables:

N/P	Six-year net births (= births - infant deaths) as percentage of base-year population (same period as for dependent variable)
$(N/P)_{-1}$	Six-year net births as percentage of base-year population, lagged one period (e.g. net births in 1970-75 as percentage of mid-1969 population, when growth in dependent variable measured from calendar 1975 to calendar 1981)
$(N/P)_{-2}$	Six-year net births as percentage of base-year population, lagged two periods
$(N/P)_{-3}$	Six-year net births as percentage of base-year population, lagged three periods
DUM(I/P)@	Dummy variable equaling one when I/P (six-year net immigration as a percentage of base-year population) exceeds 3, otherwise equaling zero
$\dot{B}$	Six-year increase in terms-of-trade index as percentage of index in base year (same period as for dependent variable)
F/Y	Six-year total of real current account deficits (before transfers) as percentage of real GDP in base year (same period as for dependent variable)
d(F/Y)	Increase between base year and end year in current account deficit (before transfers) as percentage of GDP
$\dot{U}$	Six-year increase in real US GDP as percentage of base-year US GDP (same period as for dependent variable)
dM/Y	Six-year increase in real annual mining output as percentage of real GDP in base year (same period as for dependent variable)
J	Actual exports in base year of growth period as a percentage of GDP (both in 1980 prices) minus the percentage estimated on the basis of per capita GDP, the mining share of GDP, population, and population squared; for details of the estimating equation, see Footnote 11 in text
$\dot{X}$	Six-year increase in real exchange rate index as percentage of index in base year (same period as for dependent variable)
T/Y	Six-year total of real taxes as percentage of real GDP in base year (same period as for dependent variable)
d(T/Y)	Increase between base year and end year in taxes as a percentage of GDP
E/Y	Six-year total of real military expenditures as percentage of real GDP in base year (same period as for dependent variable)
$\dot{Q}$	Percentage increase between base year and end year in index of labor force education [= sum of public education expenditures in 1980 dollars between year (t-15) and year (t-6) divided by population aged 15-64 in year (t)]
$\dot{H}$	Percentage increase in life expectancy at birth between base year and end year (same period as for dependent variable)
Z	Moslems as percentage of total population, 1983
$\bar{D}$	Mean annual deaths from political violence per million population during six-year growth period
dD	Increase between base year and end year in deaths from political violence per million population
Y/P	GDP per capita in base year of period applying to dependent variable, expressed in hundreds of US dollars of 1980 purchasing power

Outliers:

Observations	Independent variable(s) on which the observation lies more than 5 standard deviations from the mean
Egypt 1973-79	(E/Y)@
Jamaica 1974-80	dD
Libya 1968-74	[d(F/Y)]@, $\dot{X}$
Saudi Arabia 1968-74	dM/Y
Saudi Arabia 1974-80	F/Y
Singapore 1969-75	J
Singapore 1975-81	J
Uganda 1971-77	$\bar{D}$

Data sources:

For $\dot{X}$, Adrian Wood, "Global Trends in Real Exchange Rates, 1960 to 1984," World Bank Discussion Paper No. 35 (1988), Annex 3; for E/Y, Stockholm International Peace Research Institute, Yearbook of World Armaments and Disarmament; for $\dot{Q}$, UNESCO, Statistical Yearbook; for Z, Richard V. Weekes (ed.), Muslim Peoples: A World Ethnographic Survey, 2nd ed.; for $\bar{D}$ and dD, Charles Lewis Taylor and David A. Jodice, World Handbook of Political and Social Indicators, 3rd ed., vol. 2. For other variables, World Bank, World Tables; International Monetary Fund, International Financial Statistics; and United Nations, Statistical Yearbook, Demographic Yearbook, National Accounts Statistics, and Monthly Bulletin of Statistics.

A solution is to impose restrictions on the coefficient values. The first restriction attempted here requires the four net birth rate coefficients w_0, w_1, w_2, and w_3 to fit the quadratic lag function

$$w_i = v_0 + v_1 i + v_2 i^2 \qquad (14)$$

where i indicates the number of periods before the current one (i = 0, 1, 2, 3).[13] The results are shown in Column (2). Only one of the three coefficients in the lag function is significant at the 95 per cent confidence level. A second restriction is therefore tried, requiring the four net birth rate coefficients to fit the linear lag function

$$w_i = v_0 + v_1 i \qquad (15)$$

Column (3) shows that both coefficients in the linear lag function are significant at the 95 per cent confidence level, and this function is therefore retained for the remainder of the analysis performed with Models I-V.

Column (3) indicates that higher levels of fertility have a negative impact on output growth in the short run and a positive impact in the long run. Our discussion of the theoretical model of growth suggests that the negative short-run impact is due to some combination of reduced saving and reduced female participation in the labor force. The theoretical model also implies that the positive long-run impact of higher fertility is due to some combination of labor force growth and lagged Boserup effects on the rate of technological progress.

The results obtained for the fertility variables seem robust. The coefficient v_0, which by itself describes the effect of the current net birth rate on output growth, is significantly negative at the 10 per cent level in

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[13]For a discussion of this and other polynomial lag functions, see Kmenta (1986, pp. 539-42).

all of the regressions where it appears -- when the number of cases is at its maximum (Columns 2 and 3), when outliers are dropped from Model I (Column 5), when the sample is subdivided by per capita income level (Columns 6 and 7), and when various nondemographic variables are added or dropped (Columns 4 and 8-13).[14] The linear-function coefficient v_1, which describes the marginal effect of lagged fertility on output growth, is always positive and significantly so in eight out of eleven regressions. It is of particular interest to note that the respective effects of current and lagged fertility on output growth are basically similar in the high-income group and the low-income group. This clear result contrasts with the general weakness of the other explanatory variables in the low-income group, only mining growth possessing a significant coefficient.

Fertility and the Growth of Output per Capita

From a practical standpoint, it is important to know what the regression analysis implies for the effects of a fertility reduction program on output *per capita*. We have seen that fertility reduction raises the growth rate of output in the short run and lowers it in the long run. What is the net impact of these conflicting forces on the level of per capita output attained at the end of the 24-year period of analysis?

Obtaining the answer to this question is complicated by the fact that according to our regression results, an increase in per capita output achieved during one six-year period will *ipso facto* lower the growth rate of output in the succeeding period. The result in Column (3) indicates that a $100 increase

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[14]An outlier is defined here as a case lying more than five standard deviations from the mean of one or more variables.

in per capita output lowers the subsequent six-year growth rate of output by 0.159 percentage points. Our initial calculations of the effect of fertility reduction on per capita output will ignore this feedback as well as others.[15] Assume a reduction of six percentage points in the six-year net birth rate.[16] According to Column (3), a one percentage point fall in the net birth rate causes a rise of 2.242 percentage points in the growth rate of output during the six-year period. Hence by the end of this period, the assumed fertility reduction will have raised the growth rate of output by six times 2.252, or by 13.5 percentage points. If fertility remains at the lower level in the succeeding six-year period, the growth rate of output will be higher by 17.6 percentage points during those years [= 6(2.242 + 0.696)]. If the lower level of fertility persists also throughout the next two six-year periods, the growth rate of output will be higher by 12.5 percentage points during the third period [= 6(2.242 + 0.696 - 0.850)], and lower by 1.8 percentage points during the fourth period [= 6(2.242 + 0.696 - 0.850 - 2.396)]. At the end of twenty-four years, output will be higher by 47.4 percentage points, compared with the situation where there is no change in fertility. After twenty-four years of the fertility reduction the population will be about 20 per cent smaller than

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[15]One of the other feedbacks ignored in this simulation exercise is the effect of per capita output growth on fertility. The modeling of fertility is a large topic and lies outside the scope of this paper. For the purposes of the simulation exercise, it can be assumed that increases in per capita output have both positive and negative effects on fertility which roughly offset each other, or that the authorities through population policy are able to achieve whatever fertility level is desired. Yet another feedback ignored is that running from output growth to per capita output and thence to net immigration (per capita output being a determinant of instrumentalized net immigration) and back to output growth. The equation for net immigration shown in Table A.1 suggests that this particular feedback is fairly weak.

[16]The mean six-year net birth rate for all 142 cases in Model I is 19.5 per cent.

otherwise.[17] Hence its per capita output will be 84 per cent higher at that point, if output remains constant in the absence of fertility change.[18]

As noted above, this calculation exaggerates the effect of fertility reduction on per capita output because it ignores the negative feedback of per capita output changes on output growth rates. If the initial level of per capita output is $1,000, the fertility reduction raises per capita output after twenty-four years not by 84 per cent but by 82 per cent (assuming no output growth in the absence of fertility change). If the initial level is $2,000, the increase after 24 years is 80 per cent. Hence the adjustment for this particular feedback is quite minor, and does not alter the conclusion based on the regression analysis that effective family planning programs have a powerful economic payoff. This payoff is particularly evident in the framework of a benefit-cost analysis based on present values, because according to the regression results, the benefits of a fertility reduction program tend to occur before its costs.

Migration and the Growth of Output

The net immigration variable enters the regression models with estimated rather than actual values, because of the likelihood of mutual causation

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[17] This result is obtained by simulations with a demographic projections model (The Futures Group, 1987), using middling assumptions about fertility and mortality (a total fertility rate of four in the absence of fertility reduction, and a life expectancy at birth of 62).

[18] If output grows in the absence of fertility reduction, the rise in per capita output generated by fertility reduction will be smaller in relative terms. For example, if output grows by 30 per cent in each six-year period independently of fertility changes, then fertility reduction will raise per capita output after 24 years by only 69 per cent instead of 84 per cent.

between output growth and migration. When a linear relationship between this variable and output growth is assumed, no significant correlation is obtained. In reality, a nonlinear relationship seems more plausible. A country with positive net immigration of persons of working age can expect to see an increase in output, whereas one with negative immigration in that age group will not experience any decline in output if the alternative to emigration is unemployment, which is often the case. Experiments with various nonlinear formulations yield results which tend to confirm the original hypothesis: among these formulations is a dummy variable taking the value of one when net immigration during the six-year growth period exceeds 3 per cent of the base-year population. As seen in Table 1, this variable often possesses significantly positive coefficients, particularly in the models permitting the largest number of cases (I and II).

Nondemographic Determinants of the Growth of Output

A total of sixteen nondemographic exogenous variables is used in the regression models. Five of them possess coefficients which in many instances are significant at the 95 per cent confidence level and in most instances have signs consistent with the hypotheses presented in the reduced form of the growth model (Equation 12). These are the initial level of per capita output, the average level of political violence, the within-period increase in political violence, the tax rate, and the growth in mining output. Replacing the mining variable by estimated rather than actual values (Column 4) causes it to lose statistical significance but leaves the coefficients of the fertility variables essentially unaffected.

Two of the nondemographic exogenous variables carry coefficients which are nonsignificant in all of the regression models, but which nonetheless are consistent with Equation (12) in the sense that no clearcut relationship is expected. These are the military share of output and the rate of capital inflow.

Another five of the nondemographic exogenous variables carry uniformly nonsignificant coefficients which are inconsistent with the expectations expressed in Equation (12): the lagged growth in educational expenditures, the increase in life expectancy, the percentage of the population which is Moslem, the within-period increase in the tax rate, and the US growth rate. Each of these "surprises" leads to suggestions for further testing. The nonsignificance of the US growth rate, for example, may be due to the small variance possessed by this variable: in all of the ten six-year growth periods employed, the US economy was more or less sluggish. The addition of periods when the US performance was much brighter may provide a better measure of the degree to which US growth affects growth in the rest of the world.[19] The nonsignificance of the two "human capital" variables may be due to measurement problems. The lagged increase in education expenditures omits private expenditures, which are important in some countries, and the increase in life expectancy at birth may be a poor proxy for the improvement of health conditions in the labor force, which is the variable of direct interest in this context.

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[19]It may be thought that a country's sensitivity to the US growth rate would depend on its degree of openness, and that therefore the explanatory power of the US growth rate would be enhanced if each value of the variable were weighted by the exports/GDP ratio of the country in question. This adjustment was attempted, and the new variable was even weaker than the old. Similar adjustments were made for the same reason to two other variables -- changes in the terms of trade and changes in the real exchange rate -- and similar outcomes occurred.

Four exogenous variables remain, all associated with the international sector. Improvements in the terms of trade and within-period increases in the rate of capital inflow have significantly positive effects on output growth in some circumstances, but their influence is not as strong nor as universal as might be expected. Next is the change in the real exchange rate, which is a variable of substantial policy interest, since reductions in this rate are a common recommendation of the International Monetary Fund and the World Bank. These institutions back their recommendation by referring to a long series of studies and reports which purport to show that countries avoiding currency appreciation grow faster. Our regression results produce no support for this position. The coefficients on the exchange rate variable are mostly nonsignificant; when they are significant, they have the wrong sign. Nor is this outcome produced by one or two extreme observations. There is no shortage of cases tending to produce a positive correlation between real appreciation and growth. It is not difficult to find instances of rapid growth accompanying rapid appreciation (Indonesia 1968-74, Iran 1969-75, Jordan 1973-79, Taiwan 1968-74), and of slow growth accompanying real depreciation of the currency (Honduras 1868-74, Netherlands 1976-82, Peru 1975-81, Sweden 1976-82).

Finally there is export orientation, also a variable of policy interest. The Fund and Bank have generated a large amount of material in support of greater degrees of export orientation. In the regression models presented here, the coefficient on the export orientation variable usually carries the expected positive sign, but it is never significant at a confidence level of 95 per cent. Why do these results differ from those of so many other analyses of export orientation and growth? One possible answer is that the other analyses have tended to exclude current fertility as a determinant of growth. When that approach is reproduced here -- by excluding (N/P)@, $(N/P)_{-1}$, and $(N/P)_{-2}$ from the equation in Column (1) -- the t-value of the coefficient on the export orientation variable rises from 1.85 to 3.32.

Some Simpler Models

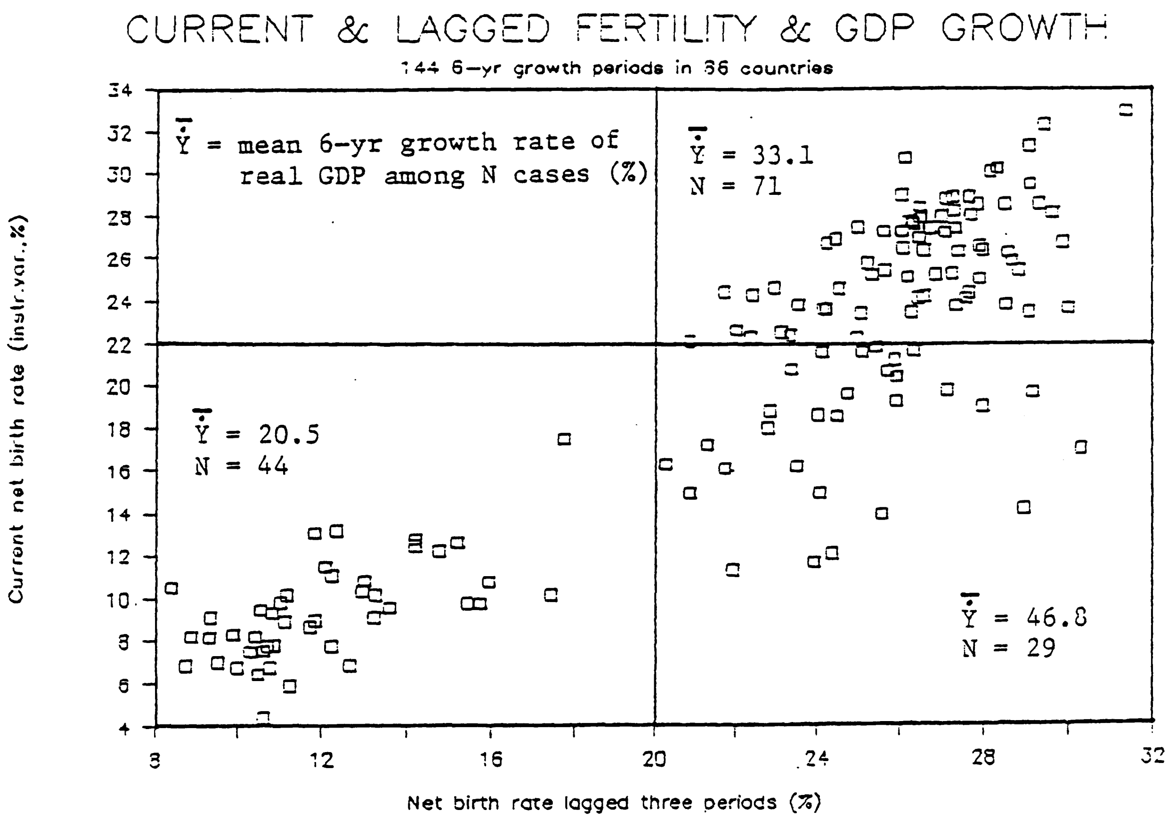
Our data set can be used to pinpoint the reasons why different models can lead to different conclusions about the relationship between population growth and economic growth. In particular, how can a simple bivariate analysis show a significantly positive correlation between population growth and the concurrent growth of output, while a multivariate analysis like the present one finds a significantly negative correlation? The bivariate model (Model VI) produces the result shown in Column (14), when all available observations are employed. But if the level of per capita output is added as a second explanatory variable (Model VII), the coefficient on the current fertility variable loses its statistical significance and becomes negative. Hence the positive and significant coefficient of the fertility variable in Model VI is spurious, and it occurs because of the negative correlation between fertility and per capita output.[20] To accept that current fertility does not have an immediately positive effect on output growth means finding a good theoretical reason why per capita output, its statistical correlate, should have an immediately negative effect on output growth. In our theoretical discussion above, we have suggested such a reason: countries with lower per capita output have available to them a relatively large backlog of unused technological improvements, so

[20]The coefficient of correlation (R) between the unlagged net birth rate and per capita output is -0.64 for the set of 142 observations used in Models I-V.

they are able to achieve a relatively high growth rate in their quality-weighted capital stock.

The negative partial correlation between output growth and current fertility is sharpened when lagged fertility is added to the equation, as in Model VIII. The coefficients of the two fertility variables exhibit the same general pattern as that observed with the linear lag function: output growth is correlated negatively with current fertility and positively with past fertility. This means that the countries with the fastest growth tend to be those with low current fertility <u>and</u> high past fertility. The point is illustrated in Figure 1, where current and past fertility are plotted for the 144 cases used in Models VI-VIII. The cases are divided into three categories: high on both current and past fertility, low on both, and low on current but high on past. The last category includes 29 cases. Their mean six-year output growth rate is 46.8 per cent, which is 18.5 percentage points higher than the mean for the other categories. The 29 cases are indicated in the Appendix (Table A.2). Well represented in the group are the East Asian tigers, both the seniors (Hongkong, Korea, Singapore, Taiwan) and the juniors (Malaysia, Thailand). According to Fund-Bank orthodoxy, an important part of the economic success enjoyed by these countries is attributable to their export orientation and currency depreciation. But the results of the present study suggest that a more important explanation lies in their fertility declines.

Figure 1


CURRENT & LAGGED FERTILITY & GDP GROWTH
144 6-yr growth periods in 36 countries
Ẏ = mean 6-yr growth rate of real GDP among N cases (%)
Ẏ = 33.1
N = 71
Ẏ = 20.5
N = 44
Ẏ = 46.8
N = 29
Current net birth rate (instr.var.,%)
Net birth rate lagged three periods (%)
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
8
12
16
20
24
28
32

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APPENDIX

Table A.1

REGRESSION EQUATIONS USED FOR ESTIMATING INSTRUMENTAL VARIABLES

Independent variables:		Dependent variables: N/P net birth rate, unlagged	I/P immigration rate	F/Y rate of capital inflow	d(F/Y) increase in rate of capital inflow	dM/Y mining growth	T/Y tax rate	d(T/Y) increase in tax rate	E/Y military share of GDP	$\dot{H}$ increase in life expectancy
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$(N/P)_{-2}$	net birth rate, lagged 2 periods	-0.432**	-0.397	-2.052	-0.853	-0.041	10.936**	0.800	-2.457	0.555**
		(0.083)	(0.234)	(2.897)	(0.708)	(1.209)	(4.518)	(0.749)	(1.523)	(0.176)
$(N/P)_{-3}$	net birth rate, lagged 3 periods	0.202**	0.223	0.189	0.499	-0.588	-3.282	-0.692	1.504	-0.204*
		(0.058)	(0.162)	(2.004)	(0.489)	(0.837)	(3.023)	(0.501)	(1.123)	(0.122)
$\dot{B}$	terms of trade improvement	0.000	0.003	-0.243**	-0.041**	0.086**	0.328*	-0.007	-0.023	-0.005
		(0.002)	(0.005)	(0.065)	(0.016)	(0.027)	(0.165)	(0.027)	(0.036)	(0.004)
$\dot{U}$	GDP growth rate in USA	0.023	0.000	-0.562	-0.084	-0.352	0.947	-0.125	-0.522	-0.042
		(0.023)	(0.063)	(0.783)	(0.191)	(0.327)	(1.078)	(0.179)	(0.439)	(0.048)
J	export orientation	0.004	0.016*	0.238**	-0.020	0.049	-0.228	0.002	0.052	0.002
		(0.003)	(0.009)	(0.109)	(0.026)	(0.045)	(0.148)	(0.025)	(0.061)	(0.007)
$\dot{X}$	increase in real exchange rate	0.000	0.000	-0.029	-0.025	-0.010	-0.128	-0.025	0.026	0.000
		(0.002)	(0.007)	(0.084)	(0.021)	(0.035)	(0.175)	(0.029)	(0.047)	(0.005)
Z	percent Moslem	0.000	-0.005	0.250**	0.053**	0.015	1.014**	0.118**	0.117**	0.013**
		(0.003)	(0.008)	(0.097)	(0.024)	(0.040)	(0.350)	(0.058)	(0.054)	(0.006)
Y/P	GDP per capita	0.010**	0.011	-0.101	-0.027	-0.151**	-0.357**	0.022	-0.057	-0.002
		(0.004)	(0.011)	(0.134)	(0.033)	(0.056)	(0.169)	(0.028)	(0.075)	(0.008)
$(N/P)_0$	net birth rate in base year	8.673**	1.150	23.179**	3.723	2.943	-44.555**	-1.630	12.613*	-1.772**
		(0.335)	(0.941)	(11.645)	(2.839)	(4.861)	(17.648)	(2.926)	(6.525)	(0.707)
$(I/P)_0$	immigration rate in base year	0.378**	3.860**	-2.414	-1.057	2.127	15.775	4.050**	5.157*	-0.260
		(0.138)	(0.388)	(4.805)	(1.171)	(2.005)	(9.737)	(1.615)	(2.692)	(0.292)
$(F/Y)_0$	capital inflow in base year	-0.008	-0.047	4.126**	-0.385**	-0.256	1.041	0.060	-0.758**	-0.006
		(0.011)	(0.031)	(0.385)	(0.094)	(0.161)	(0.771)	(0.128)	(0.216)	(0.023)
$(M/Y)_0$	mining share in base year	0.002	-0.007	-0.239	-0.153**	-0.073	-2.771**	-0.187*	0.067	0.025
		(0.008)	(0.022)	(0.278)	(0.068)	(0.116)	(0.638)	(0.106)	(0.156)	(0.017)
$(T/Y)_0$	tax rate in base year	...	...	...	...	...	6.561**	-0.235**	...	...
							(0.589)	(0.098)		
$(E/Y)_0$	military share in base year	0.010	0.043	1.411**	0.155	0.276	-1.743*	-0.219	6.231**	0.013
		(0.016)	(0.045)	(0.562)	(0.137)	(0.234)	(0.940)	(0.156)	(0.315)	(0.034)
H_0	life expectancy in base year	-0.019	-0.012	0.985**	0.138	0.231	2.023**	0.105	0.706**	-0.057*
		(0.014)	(0.039)	(0.481)	(0.117)	(0.201)	(0.859)	(0.143)	(0.269)	(0.029)
Constant term		-1.784	0.577	-71.468	-8.407	3.399	-129.799	5.248	-46.240	5.325
R^2		0.992	0.544	0.723	0.379	0.205	0.970	0.524	0.838	0.529
Number of cases		142	142	142	142	142	43	43	142	142
Number of countries		85	85	85	85	85	35	35	85	85

* = coefficient significant at 90 per cent confidence level
** = coefficient significant at 95 per cent confidence level

Definitions of variables:

The nine dependent variables and the first eight independent variables are defined in Table 1.

$(N/P)_0$ Net births as percentage of population in base year of growth period. Example: if growth period is 1975-81, $(N/P)_0$ is net births in 1975 as a percentage of 1975 population, while (N/P) is net births in 1976-81 as a percentage of 1975 population. Similar relationships between "base-year" variables and the corresponding "period" variables apply to $(I/P)_0$, $(F/Y)_0$, $(T/Y)_0$, and $(E/Y)_0$.

$(I/P)_0$ Net immigration as percentage of population in base year of growth period

$(F/Y)_0$ Current account deficit (before transfers) as percentage of GDP in base year of growth period (both in 1980 dollars)

$(M/Y)_0$ Mining output as percentage of GDP in base year of growth period (both in 1980 prices)

$(T/Y)_0$ Taxes as percentage of GDP in base year of growth period (both in current prices)

$(E/Y)_0$ Military expenditures as percentage of GDP in base year of growth period (both in current prices)

H_0 Life expectancy at birth (in years) in base year of growth period

Table A.2

COUNTRIES, PERIODS, AND GROWTH RATES ANALYSED

		Real GDP growth rate (%)			Real GDP growth rate (%)			Real GDP growth rate (%)
Algeria	1969-75	37.0	Ghana	1968-74	28.0	Norway	1976-82	20.1
	1975-81	52.3		1974-80	-9.2	Pakistan	1971-77	27.8
Argentina	1968-74	32.8	Greece	1969-75	38.1	Panama	1971-77	18.0*
	1974-80	9.4		1975-81	22.8	Paraguay	1968-74	43.7
Australia	1970-76	22.3	Guatemala	1968-74	42.5		1974-80	75.4*
	1976-82	19.0		1975-81	33.2	Peru	1969-75	36.2
Austria	1970-76	27.8	Honduras	1968-74	16.7		1975-81	14.0*
	1976-82	15.7		1975-81	42.3	Philippines	1968-74	37.8
Bangladesh	1975-81	40.2	Hongkong	1969-75	47.5*		1974-80	44.5
Belgium	1969-75	27.8		1975-81	101.8*	Rwanda	1974-80	31.4
	1975-81	13.8	Hungary	1970-76	40.3	Saudi Arabia	1968-74	106.6
Benin	1973-79	26.8		1976-82	22.0		1974-80	62.1
Bolivia	1969-75	32.9	India	1969-75	23.8*	Sierra Leone	1968-74	26.3
	1975-81	16.3		1975-81	25.4		1974-80	10.2
Brazil	1970-76	80.0*	Indonesia	1968-74	65.4	Singapore	1969-75	79.2*
	1976-82	23.9*		1975-81	57.5		1975-81	67.2*
Burkina Faso	1972-78	27.7	Iran	1969-75	55.0	South Africa	1977-83	16.2
Burma	1969-75	23.4		1975-81	-21.4	Spain	1970-76	34.8
	1975-81	43.9	Iraq	1968-74	33.0	Sri Lanka	1968-74	22.1*
Cameroon	1973-79	45.6	Ireland	1969-75	26.4		1974-80	40.6*
Canada	1969-75	30.8		1975-81	22.9	Sudan	1972-78	66.1
	1976-82	8.9	Israel	1969-75	52.1*	Sweden	1970-76	15.4
Cen.Afr.Rep.	1974-80	3.2		1975-81	16.8		1976-82	5.7
Chad	1971-77	11.6	Jamaica	1968-74	30.4	Switzerland	1970-76	2.7
Chile	1968-74	10.1*		1974-80	-14.7*		1976-82	10.9
	1974-80	24.8*	Japan	1970-76	32.1	Syria	1971-77	82.6
Colombia	1968-74	47.3		1976-82	29.0	Taiwan	1968-74	76.7*
	1974-80	35.8*	Jordan	1973-79	59.9		1975-81	74.8*
Costa Rica	1970-76	41.5*	Kenya	1970-76	62.5	Tanzania	1971-77	38.7
Cote d'Iv.	1968-74	38.4		1976-82	36.7	Thailand	1968-74	45.5
	1975-81	40.9	Korea (S.)	1971-77	79.4*		1976-82	47.4*
Denmark	1970-76	17.8		1977-83	42.3*	Tunisia	1968-74	60.5
	1976-82	9.3	Liberia	1975-81	8.5		1974-80	48.1*
Dominic.Rep.	1968-74	79.8	Libya	1968-74	-29.4	Turkey	1968-74	45.5*
	1974-80	33.3		1974-80	35.3		1974-80	25.0*
Ecuador	1968-74	76.9	Madagascar	1970-76	0.0	Uganda	1971-77	-0.9
	1974-80	44.3	Malawi	1971-77	38.7	UK	1970-76	15.1
Egypt	1973-79	62.0*	Malaysia	1970-76	57.4*		1977-83	6.2
El Salvador	1969-75	34.4		1976-82	52.9*	Uruguay	1974-80	31.6
	1976-82	-12.5	Mexico	1968-74	47.5	USA	1970-76	18.6
Ethiopia	1968-74	27.0		1974-80	45.8		1977-83	11.2
	1974-80	5.2	Morocco	1971-77	41.6	Venezuela	1969-75	18.4
Finland	1971-77	19.6	Netherlands	1970-76	23.0		1975-81	13.4
	1977-83	24.1		1976-82	5.3	Yugoslavia	1970-76	40.9
France	1970-76	27.9	New Zealand	1976-82	1.1		1976-82	29.1
	1976-82	14.0	Nicaragua	1972-78	19.4	Zaire	1968-74	33.1
Germany (W.)	1970-76	16.5	Nigeria	1975-81	4.0		1974-80	-11.9
	1976-82	12.7	Norway	1969-75	28.0	Zambia	1970-76	18.3

* = current net birth rate [(N/P)@, an instrumental variable] less than 22%, and net birth rate lagged three periods [$(N/P)_{-•}$] greater than 20%.

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