Population and Economic Growth

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The growth in the number of humans on this planet has a fascinating history (see Colin McEvedy and Richard Jones, 1978). There was negligible net growth during the first 100 or so million years of human habitation, a very low but persistent rate of growth to double the world's population during the period from about 200 BC to 1100 AD, and then a much faster population doubling again during the succeeding six centuries. Finally, population began to explode. World population doubled during the 150 years after 1700 to 1.2 billion inhabitants by 1850, doubled again during the next 100 years, and then underwent a remarkable further doubling in just 50 years to the present population of over 5 billion people.

These statistics indicate that the history of human population has two major episodes. Until about the 18th century, population was essentially stationary, with spurts of quite slow growth. But radically different trends emerged around 1750, first in England and America, and then elsewhere. Population began to grow rapidly and at increasing rates to produce an eightfold increase in total world population in under three centuries. This has raised neo-Malthusian fears of the plundering of the planet through excessive demands on natural resources, including potable water and clean air.

World incomes followed broadly similar trends, although the growth in world incomes is poorly documented until modern times. The evidence on mortality and other indicators of economic well-being strongly suggest that per capita incomes experienced little persistent growth prior to modern times. Life was short, nasty, and brutish for practically all the world's population. Per capita incomes during the 19th century even in most European nations were probably still below $300 per capita in 1998 dollars, and Europe was the richest continent at that time.

Therefore, over the vast majority of historical time, minimal increases in world population went together with negligible growth in real per capita incomes. And both "took off" in the 19th century, as a rapid growth in per capita incomes matched the spectacular growth in population.

Thomas Malthus argued convincingly that the low and generally rather stationary level of world per capita incomes prior to his time (the end of the 18th century) was causally related to the very slight rates of growth in population. According to the Mathusian model, the causation went in both directions. Higher incomes increased population by stimulating earlier marriages and higher birth rates, and by cutting down mortality from malnutrition and other factors. But higher population also depressed incomes per capita through diminishing marginal productivity. This dynamic interaction between population and the economy is the heart of the Malthusian model of income and population determination. It implies a stationary population in long-run equilibrium.

However, much of what has occurred since the beginning of the 19th century is clearly inconsistent with crucial tenets of the Malthusian analysis. As per capita incomes of many nations grew, fertility did not increase, as predicted by Malthus, but eventually began to fall sharply. Although population did grow as incomes grew, its rapid expansion since the

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19th century was not sufficient to prevent per capita incomes from continuing to rise.

The Malthusian model was abandoned by most 20th-century economists, but its principle legacy, that higher population tends to reduce per capita income, lives on in the neoclassical literature through the assumption of diminishing marginal product to greater labor supply. In the modern view, the growth in per capita income during the past 150 years has little to do with population and, rather, is caused by the accumulation of human and physical capital and the discovery of new technologies.

We believe the relation between population and per capita income is far more complicated than that found in either Malthusian, or neoclassical and endogenous-growth, models. Under conditions that tend to prevail in poorer, mainly agricultural, economies with limited human capital and rudimentary technology, higher population usually does tend to lower per capita incomes, mainly along Malthusian lines.

However, these Malthusian effects would be much weaker in modern urban economies with small agricultural and natural-resource sectors. In these economies, the increased density that comes with higher population and greater urbanization promotes specialization and greater investment in human capital, and also more rapid accumulation of new knowledge. These "increasing returns" from specialization and accumulation of knowledge would raise per capita incomes as population grew and are likely to be far more important than diminishing returns in resource-constrained sectors.

In this short paper, we only sketch out a few features of our ongoing research on population and growth. We relate population to cities, investments in human capital, and economic growth. Although we do not explore this, our analysis has similar implications for the effects of higher population density on per capita incomes and other variables in different countries and other geographic regions.

I. A Simple Model

In our model, parental heads of dynastic families make three choices: they consume, have children, and invest in the human capital of their children; we ignore physical capital in this presentation. Parents allocate a fixed portion of time (denoted T) between producing current consumption and producing children.

The budget constraint is $T = \ell + nh$, where ℓ is time spent in the labor market, n is the number of children, and h is the time spent on producing and rearing each child. Rather than explicitly modeling a utility function and a value function for a dynastic family (we sketch such an approach in Section II), we first assume the simpler parental utility function $U(c, q, n)$, where c is consumption, q is the human-capital level of each child, and n is the number of children. In particular, we assume a utility function that is separable between current consumption {denoted $u(c)$}:

$$U = u(c) + an^{1-e}V(q)$$

where e is the constant elasticity of parental utility with respect to number of children.

Population enters by affecting the production of consumer and investment goods. Consumer output is assumed to be a function of time spent working by each person and the number of persons, as in $c = c(\ell, P)$. The production of consumption goods might be subject to diminishing returns as population grows because increases in population require the stock of natural resources, such as oil or land, to be shared over a larger population. However, greater population levels could produce positive spillovers, through greater specialization among workers in the consumer sector.

In addition to the agricultural (or more generally the natural-resource-based) sector, there is an urban (or manufacturing) sector. Population raises productivity in the urban sector, perhaps primarily by increasing population density or reducing the space between individuals. We do not consider any forces leading to diminishing returns in the urban sector because the knowledge, human capital, and goods produced there are not much dependent on natural resources.

Human capital is produced primarily in the urban sector, so that the effect of population on the production of children's human capital depends not only on parental time and parental human capital, but also on population density,

as in $q_t = I(h_{t-1}, q_{t-1}, P_t)$, with $dq/dP > 0$. Population density is likely to raise the production of human capital because greater density leads to a finer division of labor by "extending the market," and by reducing the costs of coordinating specialists. This improved division of labor raises the productivity, or effectiveness, of the children's human capital.

Thus, population density has a possibly negative productivity effect in the consumption sector, and a positive effect in the human-capital and knowledge sectors. Population density has been extensively discussed in the urban-economics literature. Traditional models (e.g., Paul Krugman, 1991; Antonio Ciccone and Robert E. Hall, 1996) emphasize its effects on production, while a newer literature (e.g., Glaeser, 1999) tends to argue that more densely populated cities speed the accumulation of human capital.

The first-order conditions for consumer maximization of the utility function given above are

$$U'(c)dc/d\ell = \frac{a(1-e)n^{-e}V(q)}{h}$$

$$= an^{-e}V'(q)dq/dh.$$

We assume general concavity conditions which are sufficient to ensure that this is a maximum. The marginal benefit of time spent producing current output should be equal to the marginal benefit of that time spent either having more children or raising the human capital of each child.

We can eliminate fertility from the middle and right-hand side to get an equation that depends only on the optimal investment in each child and population:

$$(1-e)/v = E(q, P)$$

where v is the elasticity of V with respect to q, and $E = d \ln q/d \ln h$ is the elasticity of q with respect to h. If v as well as e is constant, the left-hand side is a constant determined by these parameters. Then, an increase in population raises investments in the human capital of each child if E is declining in q and rising in P. This condition does not necessarily hold, since an increase in population could raise the marginal product of time spent investing in human capital (dq/dh) (which is plausible) without increasing its elasticity ($d \ln q/d \ln h$).

This simple framework provides a number of additional conclusions. Population density will obviously increase parental utility if it has a sufficiently positive effect on human-capital accumulation, or if the effect on current production is not too negative. Since human capital is more important at higher levels of development, greater population is likely to raise per capita welfare in more developed societies.

An increase in population density may lower the productivity of farming in poorer agricultural economies, so that per capita output there would be lower initially. However, even in these economies, greater density would tend to raise the accumulation of human capital by raising rates of return on investments in schooling and other human capital. Moreover, families would eventually lower their fertility if population growth raises rates of return on investments in children, because that would increase the shadow cost of having large families compared to investing more in each child.

Therefore, the "demographic transition" toward smaller families in economies with initially high fertility and low per capita incomes may be stimulated by an initial growth in population. When population starts to climb, perhaps due to a fall in mortality, that may both reduce fertility and raise the accumulation of human capital.

II. A Growth Model with Population

We derive these and other results in a fuller model of economic growth that includes both diminishing returns to consumption from greater population density and increasing returns to investments in human capital. We build on the three-sector model of growth in Becker, et al. (1990). Parents choose their number of children and investments in the human capital of each child to maximize dynastic utility:

$$U(H_t) = u(c_t) + an^{1-e}U(H_{t+1})$$

where H_t is the human capital of generation t. U_t is maximized subject to a similar time-budget constraint to the one introduced in Section I, and to a production function for H_{t+1} that depends on time spent in "teaching" and the human capital of "teachers" (H_t).

This modified model has a Malthusian position with stationary per capita incomes and no investment in human capital ($H = 0$). But unlike the corresponding equilibrium in Becker et al. (1990), diminishing returns to population in the consumption sector now require equilibrium population also to be stationary. This is consistent with the weak population growth during most of recorded history.

Population would be stationary in a closed economy only if births just offset deaths. The very high birth rates in poor economies have been consistent with little population growth because of high mortality during childhood and at adult ages, often due to epidemics and wars.

This Malthusian equilibrium is locally stable, but as in Section I, mortality and other shocks to population, as well as improvements in technology, could encourage investments in human capital. If this equilibrium is destabilized and the economy begins to develop, families start investing in human capital, cities grow in importance, and specialization increases.

The economy has more access to increasing returns to scale as a larger fraction of the population moves to cities. Concentration of population in cities is important to economic development because cities have an extensive division of labor and produce most of the human capital and additions to knowledge. Moreover, their high population density is crucial to their well-developed specialization by skills, and their production and transmission of knowledge.

A larger population may help overcome possibly diminishing returns to this generation's human capital in the production of the next generation's human capital, because greater density induces more specialization and a larger market that raise returns to human capital and knowledge. Suppose, therefore, that these returns do not diminish as the stock of human capital grows, perhaps because population increases sufficiently rapidly as human capital grows. Then, an economy that is shocked away from a Malthusian equilibrium would tend to approach a steady-state growth path that has a constant rate of growth in human capital per capita. If human capital per capita is sufficiently large, the economy would move to steady-state growth.

Along the steady-state growth path, consumption per capita would increase at a slower rate than human capital if population is growing, and if the production of consumer goods has diminishing returns to population. However, consumption per capita can still be increasing, despite these diminishing returns, if the positive effect of the growth in human capital on productivity in the consumption sector more than offsets the negative effects of population growth. In other words, zero population growth is not necessary for sustainable growth in per capita consumption, even with diminishing returns to population in the production of consumer goods.

Some of those who favor zero, or only very slow, population growth recognize that advances in knowledge and technology in the past offset the negative effects of population growth and produced growing per capita incomes. But they worry about whether these advances can be expected to continue in the future, and they argue that it is necessary to plan ahead for declining rates of technological progress.

Those are legitimate concerns, but they implicitly assume that rates of technological advance are essentially independent of population growth. However, returns to specialization, to cities, and to R&D (see e.g., Michael Kremer, 1993) may all be positively related to population levels and population density. Therefore, if rates of return on investments in human capital and the accumulation of knowledge significantly increase as population increases, it is not surprising that greater knowledge and human capital in the past more than offset the effects of higher population on diminishing returns.

Our analysis has the empirically supported implication that birth rates are lower in the modern world with growing human capital than they are in traditional agricultural Malthusian-type economies. Yet lower birth

rates are consistent with more rapid population increase in modern economies because mortality is so much lower than it was in the past. Indeed, our analysis also implies that birth rates are lower in modern economies partly because adult and child mortality is so much lower.

However, birth rates could become so low relative to mortality that the steady-state rate of population change could be negative. In fact, fertility is presently below its replacement levels in more than a dozen countries. Declining populations could eventually have a significantly negative effect on specialization and other determinants of productivity.

III. Conclusions

With a few notable exceptions, economists, along with others, have believed that greater population lowers per capita incomes through diminishing returns. However, there is little empirical evidence that higher population in more developed economies reduces per capita incomes.

Our analysis incorporates positive as well as negative effects of population on productivity. Population may reduce productivity because of traditional diminishing returns from more intensive use of land and other natural resources. However, larger populations encourage greater specialization and increased investments in knowledge, mediated in part through bigger and more important cities. Therefore, the net relation between greater population and per capita incomes depends on whether the inducements to human capital and expansion of knowledge are stronger than diminishing returns to natural resources.

The potential importance of increasing returns to population in a world with rapidly growing population justifies a reconsideration of the relation between population and per capita incomes. That is the goal of the larger study that underlies our presentation in this paper.

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