Comparative ecomomic growth: evidence and interpretation

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Abstract. This paper reviews the major facts of comparative per capita economic growth over the 1960–88 period, drawing attention to the unprecedented rates of growth achieved by the fastest-growing economies and the consequent unprecedented variation in economic growth across countries. The paper also discusses the major economic explanations for cross-country variations, including traditional capital accumulation, technological 'catch-up' and endogenous technological change, demographic change in combination with natural resource depletion, human capital investment, and government policy. All of these factors have explanatory power, but much of the variation remains poorly understood.

Croissance économique comparative: faits et interprétation. Ce mémoire fait une revue des faits connus sur les comparaisons entre taux de croissance économique per capita pour la péroide entre 1960 et 1988. On attire l'attention sur les taux de croissance sans précédents réussis par les économies dont la croissance a été la plus rapide, et sur la grande variation inédite des taux de croissance entre pays. L'auteur examine les principales explications économiques de ces variations entre pays, y compris celles qui dépendent de l'accumulation du capital, du rattrapage technologique et du changement technique endogène, du changement démographique combiné à l'épuisement des ressources naturelles, de l'investissement en capital humain, et des politiques gouvernementales. Tous ces facteurs ont un certain pouvoir d'explication mais le gros de la variation des taux de croissance entre pays demeure mal compris.

I. INTRODUCTION

In retrospect, we can reasonably assert that the dominant economic event of the

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period between the world wars was the Great Depression of the 1930s. Selecting the dominant economic fact of the current period (covering, let us say, from 1960 to the early 1990s) would be more difficult. One candidate would be the apparent victory of market capitalism over central planning as an economic system. Another possible candidate might be the emergence of global environmental degradation as an important economic phenomenon. A third candidate would be the 'internationalization' of the world economy: the dramatic movement towards economic interdependence between nations, as reflected by the increased relative importance of international trade, investment, financial transactions, and migration.

As most readers will have inferred from the title of this paper, however, I will argue that the dominant economic fact of the current period is none of these but is instead the unprecedented variation in economic growth across countries that has occurred over the past thirty years. Whether this pattern of cross-country growth will have as significant and long-lasting an impact on the evolution of economic thought as the Depression had is not yet clear. Increasing awareness of the surprising pattern of comparative economic growth has, at the very least, breathed new life into both the theory and the econometric investigation of economic growth. The salient facts of comparative economic growth are, however, still not as widely appreciated as they might be.

This paper has two principal objectives. First, it seeks to draw attention to the important stylized facts of comparative economic growth. Second, it offers a discussion of the major economic explanations for the pattern of comparative growth that we have recently observed. Explaining this pattern is a major intellectual challenge. Economists have sought to explain it by looking at variations in capital accumulation, technological change, demographic change, natural resource availability, human capital, and government policy.

Simple growth accounting seeks to attribute, as an accounting exercise, economic growth to a subset of these factors, usually treating one of them, such as technological change, as a 'residual.' Thus economic growth is necessarily 'explained' by the underlying proximate economic factors. While such exercises are useful, they do not provide a satisfactory theoretical explanation of the growth process. The task of economists is to explain the evolution of the proximate causal factors of growth, particularly technical progress, as the outcome of more basic individual and market level economic processes and incentives. Much of the recent innovation in economic growth theory seeks to do precisely this. We can then ask whether these economically more complete descriptions of the growth process are consistent with the comparative growth that we observe.

Focusing on the endogeneity of technological progress does seem to offer considerable potential for understanding the striking variation in economic growth across countries. This paper also emphasizes the role of natural resource depletion and demographic change in explaining comparative performance. The value of these and other lines of research notwithstanding, fully explaining the recent cross-country variation in economic progress remains a substantial intellectual challenge at this stage.

An outline of the paper is as follows. Section II describes the stylized facts of comparative growth. Section III discusses capital accumulation and traditional growth theory, and section IV considers endogenous growth theory. Section V addresses demographic change and natural resource availability, section VI examines the possible role of human capital, and section VII discusses government policy and other aspects of political economy. Finally, section VIII provides some concluding remarks.

II. EVIDENCE ON COMPARATIVE GROWTH

The easiest way to describe the data is by way of some simple diagrams. The data used in the diagram are drawn from Mark 5 of the Penn World Table (denoted PWT 5) as described by Summers and Heston (1991). This 138-country data set is the product of a long-term effort undertaken by Robert Summers and Alan Heston (and initially by Irving Kravis) of the University of Pennsylvania, in conjunction with the United Nations Income Comparison Project (ICP). The objective is to develop real output and related economic data series that can be used for meaningful cross-country and intertemporal comparisons.[1]

The principal innovation is to correct national income accounts for variations across countries in the relatives prices of non-traded goods, making the Penn World Table a much better source for comparisons of real income than standard national income measures converted to a common currency using market exchange rates. The major comparative effect of using purchasing power corrected income is that low income countries tend to emerge with higher real incomes, reflecting the fact that non-traded goods tend to be relatively cheaper in such countries. In addition, countries such as Japan and Switzerland that have very high prices for land and other non-tradeables have somewhat reduced incomes relative to, for example, the United States and Canada.

Figure 1 shows the ratio of 1988 per capita real output[2] to 1960 per capita real output for a set of countries taken from PWT5. This ratio must be positive, with negative growth rates showing up as growth ratios of less than 1. Several facts are evident from figure 1. First, a group of countries including Taiwan, Hong Kong, S. Korea, Japan, and Singapore (not on the graph) have achieved remarkable and historically unprecedented growth rates of per capita output and income over the

1 There are many index number problems associated with such data construction exercises. We are fortunate in Canada to have some of the leading contributors to index number theory and aggregation. See, in particular, the collected works (on index numbers and related topics) of Erwin Diewert edited by Diewert and Nakamura (1992) and also Blackorby, Primont, and Russell (1978). Acknowledging that such problems continue to exist, the Penn World Table at least corrects several significant problems associated with using national income accounts to make cross-country comparisons.

2 The Penn World Tables provide several measures of per capita GDP, and provide a series of conversion factors from which one can obtain per capita GNP. At the level of resolution of these diagrams it does not matter which series is chosen. For the record, however, I am using the RGDPCH series favoured by Summers and Heston (1991) for time series comparisons. Strictly speaking, this is an output series but I shall occasionally refer to it as 'national income.'

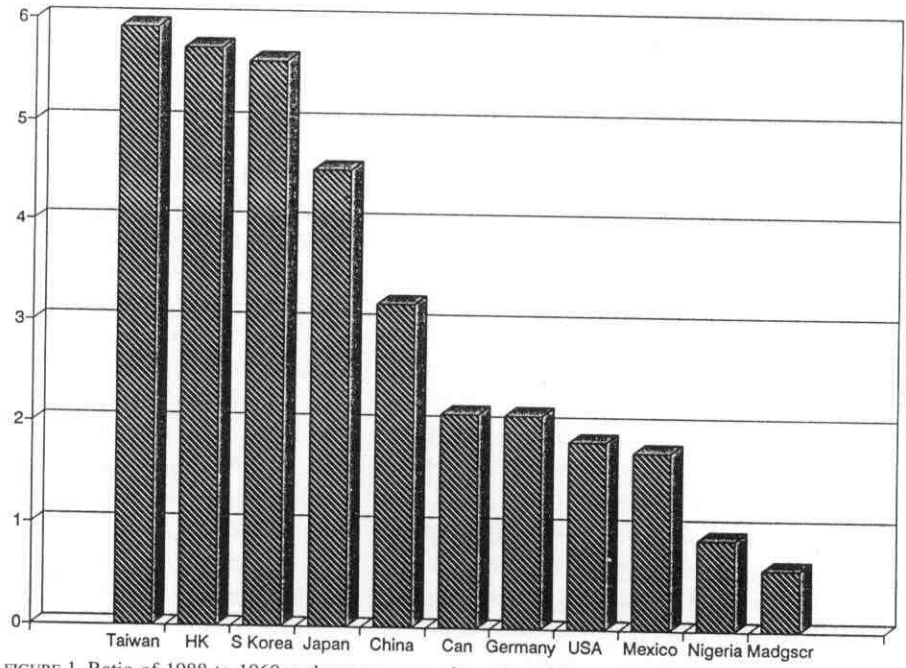

FIGURE 1 Ratio of 1988 to 1960 real output per capita: selected international comparisons

past thirty years. In that short period of time standards of living in these countries have increased by factors of 5 or 6, totally transforming the very nature of living for most of the population. It would not be a gross exaggeration to argue that in some of these countries the standard of living for an average person has changed more in the past thirty years than in the previous 300.

The corresponding annualized growth rates of per capita output (not shown on figure 1) for Taiwan, Hong Kong, and South Korea in this period (1960–88) have been between 6 and 7 per cent per year. To put things in perspective, recall that the fastest annualized rates of per capita income growth achieved by European or North American countries during and immediately after the industrial revolution were on the order of only 2 per cent per year. The highest rate reported in, for example, Kuznets's (1971) compilation of growth rates for the eighteenth and nineteenth centuries was the 2.1 per cent annualized growth rate achieved by France in the period of 1831–70. Even so, the European and North American growth rates were truly revolutionary in that they themselves were dramatically faster than they had been historically and were dramatically faster than elsewhere in the world. However, a revolution that took a century in Europe has taken only about thirty years in the market economies of eastern Asia.

Looking to more modern times, the fastest rate of growth achieved in western Europe over the period of a decade was in West Germany, which had an annualized per capita growth rate of about 6.6 per cent per year during the 1950s, approximately doubling per capita real income and output over the decade. The next doubling took about twenty years. Over the 1950–80 period as a whole, therefore,

Germany achieved output growth that was remarkable by any reasonable standard but still somewhat slower than the recent growth obtained in Taiwan, S. Korea, Hong Kong, Singapore, and Japan.

While discussing high growth rates, we would be remiss in overlooking China, which registers strong per capita growth on figure 1. What figure 1 does not show is that China's growth should be divided into two subperiods. China undertook a major policy reversal in 1976, when the period of market suppression associated with the Cultural Revolution ended[3] and a period of market-based liberalization began. Between 1960 and 1976, annualized per capita output, starting from a very low base, grew (on average) at a modest but respectable rate of about 1.7 per cent per year. Between 1976 and 1988 China recorded a stunning annualized per capita output growth rate of about 7.2 per cent per year, making it the world's (or at least PWT5's) fastest growing economy over this period. By 1991 per capita income and output were triple the 1976 level.[4] This growth rate is particularly remarkable in view of the fact that China's population, at over 1 billion, represents more than one-sixth of the world's population. In addition to the Asian countries already mentioned, Malaysia, Thailand, and Indonesia have also experienced very rapid growth of per capita output over the past decade. The first major question that emerges from the data, therefore, concerns how such high growth rates of per capita real income and output were achieved.

Another noteworthy fact illustrated by figure 1, as foreshadowed in the introduction to this paper, is the very high variance in per capita economic growth. In contrast to the high rates of growth achieved in some parts of Asia during the 1960–88 period, there was very disappointing performance in some other regions. Figure 1 includes two countries in subsahara Africa. Nigeria, the largest country (by population) in Africa, registered a decline in per capita output of about 10 per cent over the period, making it representative of the aggregate experience in subsahara Africa. Madagascar, the worst-performing of the 138 countries in PWT5, suffered a decline of some 40 per cent in per capita output over the 1960–88 period. Across the world as a whole, growth rates were scattered broadly over the range from serious decline to stunning growth, with annualized growth rates for the full twenty-eight-year period varying from Taiwan's high of 6.4 per cent to Madagascar's low of 1.8 per cent. Given that the positive growth rates are so high by historical standards, it follows that the variation in economic growth across countries has been at an unprecedented level over the past thirty years.

Both the amount of variation and the distribution of variation are dramatic and surprising and were not well predicted by economists in the early 1960s. If one

3 The 'official' dates of the Great Proletarian Cultural Revolution are 1966–8. However, the economic and social policies associated with the Cultural Revolution, including vigorous suppression of markets, dominated China until the death of Mao Tse Tung in 1976. The process of liberalization had begun before the death of Mao, but 1976 is certainly the best year to take as the 'break-point' in Chinese economic policy.

4 The Penn World Tables (Version 5) go up to only 1988. This statement relies on augmenting the Penn World Table with growth rates obtained from the *Economist Intelligence Unit Country Report* for China, 1989–92.

looks at the development literature of the early 1960s there is considerable pessimism, for example, about prospects in Eastern Asia. Consider the following quote from the Food and Agriculture Organization of the UN (1963). The question addressed by the quote is whether food production in what were then referred to as the 'underdeveloped regions'[5] could rise sufficiently to match population growth up to the year 2000: 'In Latin America and Africa, the physical resources are unquestionably ample, without approaching their full utilization ... In the Far East the balance between future food needs and known potentialities for production may well prove to be delicate.' The basic point of this quote is that prospects for East Asia were viewed by many reasonable people as more problematic than those for Africa. This illustrates the general failure to anticipate the enormous difference that would emerge in relative economic performance between eastern Asia and subsahara Africa.

Rosenstein-Rodan (1943) and Rostow (1961) developed (relatively descriptive) theories of growth based on a 'big-push' or 'take-off' characterization of development, which seem to have some ex post descriptive accuracy. These theories, while not well developed analytically, are earning more respect now than they did in the 1970s and 1980s. However, they were not very good at predicting which countries would take off or how much they would grow. I note in passing that Rostow's characterization of growth emphasized the role of a 'leading sector' and is similar to the 'staples thesis' put forward much earlier by Harold Innis (1927), after whom the Innis Lecture is named.

Figure 2 addresses the so-called 'convergence' question. The empirical question concerns whether there is a tendency for lower-income countries to 'catch up' to or converge on higher income countries. If so, then a plot of per capita real output growth vs. initial per capita output should have a negative slope. Figure 2 shows such a plot for the 1960–88 period for 116 countries drawn from PWT5.[6] OECD countries are marked with circles around the corresponding points. I am not sure that I see a negative slope in figure 2, although a 'seeing-eye' regression package might. The convergence question has, of course, been addressed by many researchers, including Abramovitz (1986), Baumol, Blackman, and Wolff (1989), Dowrick and Nguyen (1989), and Helliwell and Chung (1992) among others. It is fairly well established that there is convergence among OECD countries, or among some closely overlapping group consisting mainly of higher-income countries.[7] The

5 The term 'under-developed' fell into political disrepute as it was viewed as a slur on the regions so designated. Even the term *less developed*, while widely used, is regarded as politically suspect by some. Politically correct terminology is to refer to poor countries as 'developing nations,' even though many of them have not been developing, and to refer to higher-income regions as 'industrialized' countries, even though many of them are not primarily industrial. I prefer the (more accurate) World Bank approach of referring to countries as high or low income.

6 The basis for dropping countries included missing data, very unreliable data, and one or two conceptual issues leading to dropping some OPEC countries and some very small countries. Virtually all market-based economies of reasonable size, except some OPEC countries, are included. I have filled in a few pieces of missing data for 1987 and 1988 using IMF and World Bank data.

7 It is clear, of course, as pointed out by de Long (1988), that if one uses ex post high income as the basis for selecting the sample, then apparent convergence will be induced by sample selection

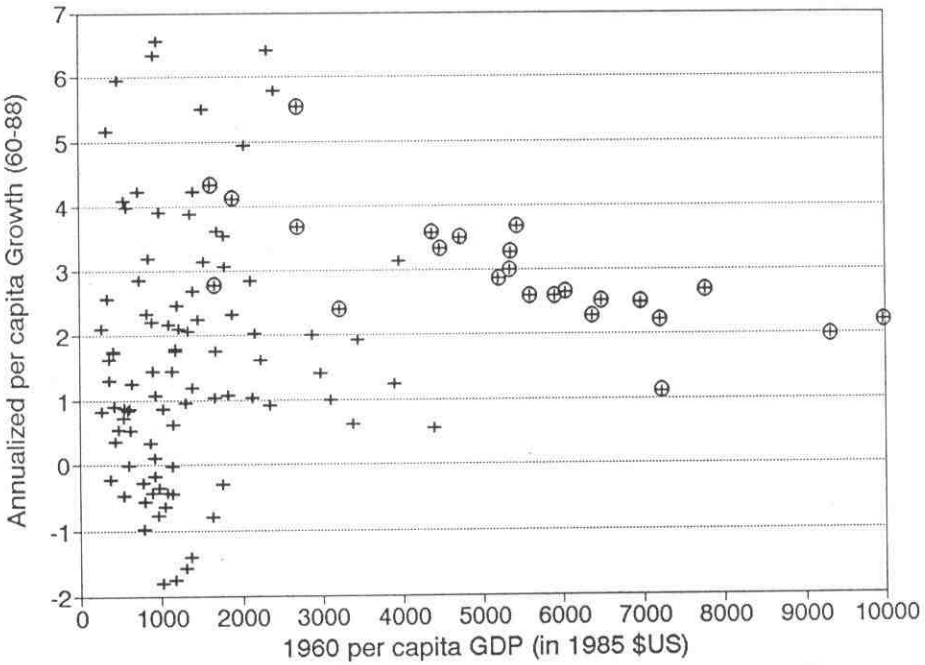

FIGURE 2 Convergence? Annualized per capita real output growth rates versus initial per capita output

(circled) OECD subset does show a clear downward slope. Also, rather obviously, there is catch-up between the rapidly growing east Asian economies and the OECD. There is not only an absence of catch-up between subsahara Africa and the OECD, however, but an actual 'falling-behind'; and Latin America has just been 'holding its own' in growth rates but not converging on the OECD in income level.

Dowrick (1992) has argued that evidence for the world as a whole favours divergence rather than convergence. Helliwell and Chung (1992) have asked whether there is catching-up within four subgroups: the OECD, Asia, Latin America, and Africa. In addition to confirming catch-up in the OECD, they find catch-up within Latin America, weak catch-up within Africa, but no catch-up within Asia. Adding to the puzzle is that country-specific 'case-study' work suggests that technologically based catch-up is crucial. The apparent reason for rapid growth in South Korea, for example, is the replacement of traditional technology with more modern technology, allowing a rapid approach on 'best-practice' production methods.

One such example, described in Magaziner and Patinkin (1989), is the South Korean domination of the world microwave oven market.[8] In 1976 microwave ovens were not produced in South Korea, but a Korean company named Samsung purchased a microwave oven called the Jet 230, made by General Electric, the

bias. However, these problems would seem to be solved by focusing on a well-defined prior grouping, such as OECD countries.

8 I thank Scott Taylor for suggesting this example to me.

leading American appliance company. An engineer at Samsung was given fifteen square feet in the corner of a lab and told to figure out how the Jet 230 worked and to build a copy. As one would expect, his first copy melted, as did the second. In 1978, two years after buying the Jet 230, Samsung managed to build a working microwave oven. In 1979 it sold its first ovens, and in 1980 it penetrated the U.S. market for the first time, selling roughly 1,000 ovens.

Samsung grew rapidly but was at somewhat of a disadvantage relative to Japanese rivals, because it could not produce a key component called a magnetron but instead bought magnetrons (at a high price) from a Japanese supplier. In 1983, however, Samsung bought the last U.S. magnetron factory, which had just gone bankrupt, moved its equipment to Korea, and was able to learn from this transplanted factory how to produce magnetrons. By 1987 Samsung was the world's leading producer of microwave ovens, with 20 per cent of the world market share, representing some 5 million units sold in the year. Samsung earns substantial profits from its microwave business and supports a large work force at incomes that would have been unthinkable only a decade previously. This is a classic story of rapid technology transfer through reverse engineering, and it has occurred many times in South Korea and in eastern Asia generally. But if it is so easy, why has it not happened everywhere? The stylized fact is that technological catch-up seems to be important for some countries, but does not characterize the world as a whole.

Two other variables that are often linked to per capita output growth are population growth and investment. Figure 3 shows annualized per capita output growth vs. population growth over the 1960–88 period, indicating a negative relationship, but with a lot of variation around it. Figure 4 is a plot of per capita output growth versus the average investment rate (INV/GDP), showing a fairly strong positive relationship.

Figure 5 addresses another well-researched question. Is there a growth slowdown evident in the data? The upper line shows world (at least the 116-country world) per capita output growth at annualized rates taken over five-year intervals from 1960 to 1985 and the three-year interval 1985–88. The lower line shows corresponding per capita income growth just for Africa.

The world as a whole has achieved roughly a 3 per cent annualized per capita growth rate over the recent past. Income growth peaked in 1965–70, then fell. However, the most recent period (1985–8) seems to have restored high growth. This is not an obvious slowdown. There are, however, some additional factors to consider. First of all, a major outstanding problem with additional income data is the failure to account accurately for resource depletion and environmental degradation. (See, in particular, Ahmad, Serafy, and Lutz 1989.) For example, if a stand of timber is cut down to produce pulp, the full value of the pulp is counted in national income, but no subtraction is made for the asset that was 'used up' in the process of producing pulp.

Conceptually, it is clear that resource depletion should be treated as a subtraction from gross output to achieve net output, just as it is with depreciation on the capital stock. When the activities of human beings were modest in scope compared with the availability of natural resources, ignoring this effect was of minor significance, but the scale of resource depletion effects is now of such a magnitude as

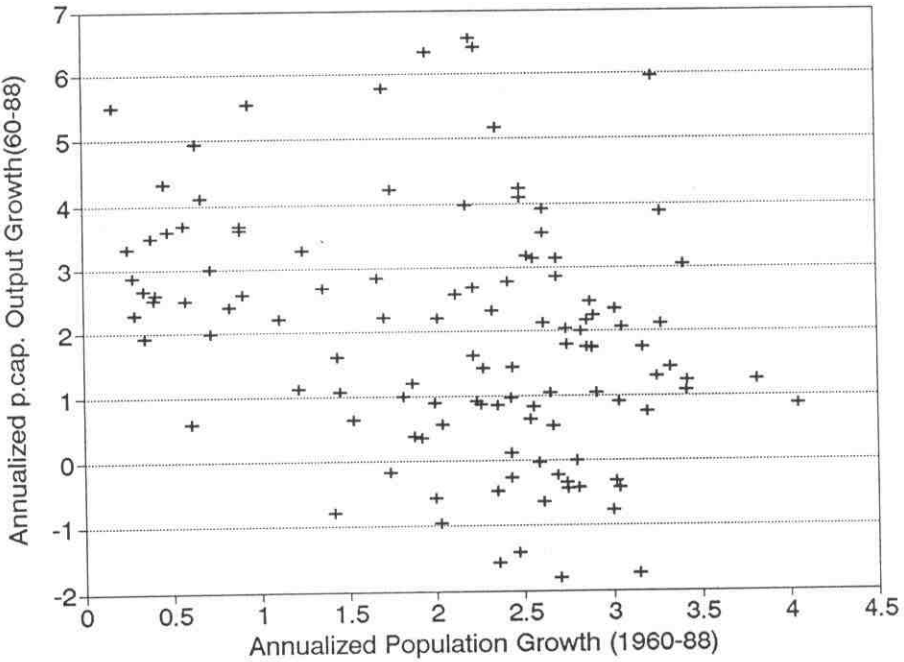

FIGURE 3 Annualized per capita output growth rates versus annualized population growth rates

to represent a major error in national income accounting. Properly accounting for environmental effects[9] would substantially lower recent measured income growth rates. A study for Indonesia (Repetto et al. 1989) suggests that annualized aggregate income growth for the 1971–84 period would fall from about 7 per cent to about 4 per cent, implying that per capita income growth would fall from about 5 per cent to about 2 per cent. (See also Peskin and Lutz 1990.) In addition, the usual problems (accounting for leisure, accounting for new products, account for non-market productive activity, and accounting for marketed non-productive – e.g., lawyers) provide major qualifications.

Problems associated with new products and with leisure probably tend to make us understate growth in all periods; the other problems probably tend to make us overstate growth in all periods. I believe, however, that all factors, particularly the environmental adjustment, would lead to a greater overstatement of growth in later periods than in earlier periods, suggesting that there might be an aggregate 'slowdown.'

Second, when the data set is extended to the full five-year interval (up to 1990) the growth rate for the last point will likely drop, based on existing data from the World Bank and IMF. Furthermore, based on what we know about the first three

9 It is far from clear how to account fully for natural resource depletion, especially in view of concerns about intergenerational equity and the desire to maintain a reasonable long-run or 'sustainable' supply of basic natural resource services. One interesting approach is developed in von Amsberg (1992).

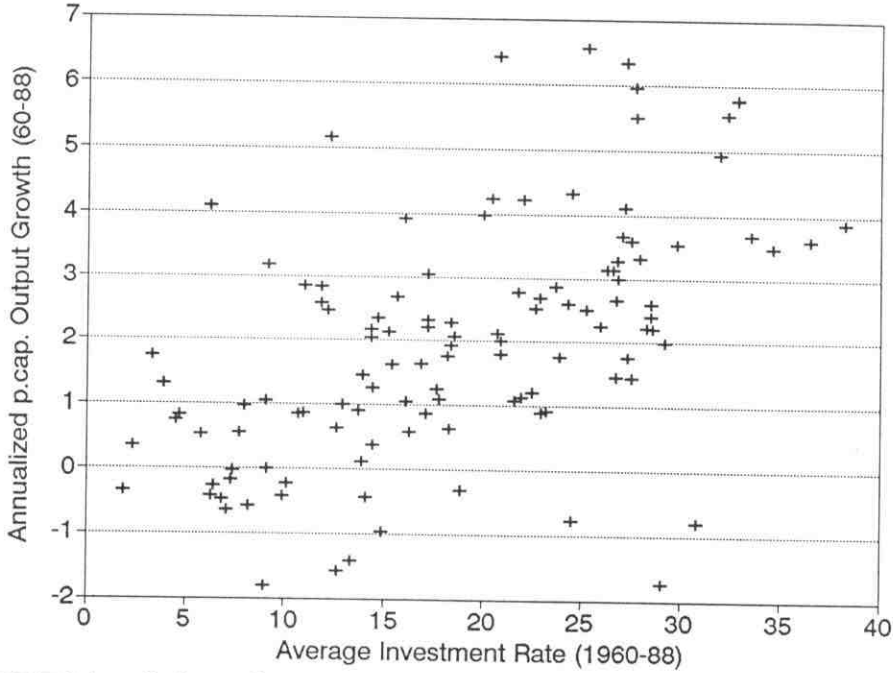

FIGURE 4 Annualized per capita output growth rates versus average investment rate (1960–88)

years of the 1990 (mid-year) to 1995 (mid-year) period, it appears that per capita growth, even as conventionally measured, will drop sharply. In the United States (which contributes a lot to the aggregate)[10] and Canada, real capita output growth for mid-1990 to mid-1992 is negative, and other major contributors like China, Japan, and Germany are experiencing slower output growth in the early 1990s than in the previous decade.

My guess is that when we have another half-decade of data and more systematic environmental adjustments, a secular slowdown starting from the peak in 1965–70 will be evident. Furthermore, if we turn to Africa, we see a dramatic slowdown even in existing data, with each half-decade since 1965–70 showing slower (or more negative) growth in per capita output.

III. TRADITIONAL GROWTH THEORY AND CAPITAL ACCUMULATION

For most economists the natural starting point for understanding economic growth in the one-sector neoclassical growth model developed by Solow (1956) and by Swan (1956).[11] The model is very simple and assumes neoclassical constant returns in two factors, capital and labour, with each factor exhibiting diminishing marginal

10 A little algebra shows that aggregate 'world' per capita income growth can be thought of as the weighted sum of each country's per capita income growth, with the weights being given by each country's share of world real income.

11 I observe in passing that many current growth theorists, especially in North America, do not make

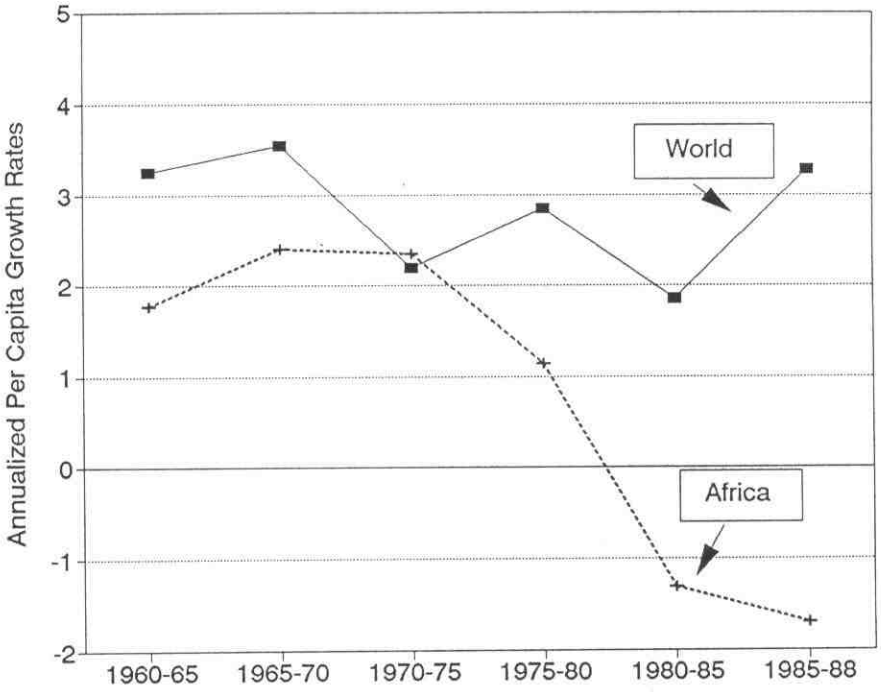

FIGURE 5 World and African per capita real output growth: annualized rates for half-decades 1960–88

productivity. The economy is perfectly competitive and is driven by an exogenous savings rate and by exogenous labour force (and population) growth.

Both Solow and Swan understood the model to be 'unrealistic' in the sense that it abstracted from important considerations. The beauty of the model, however, is precisely in its parsimony. The model was able to deal with the immediate motivation for writing these papers, which was to address problems raised by Harrod (1939) and Domar (1946) about the internal consistency of a certain class of dynamic models. In addition, it served as the central building block for a very large subsequent empirical and theoretical literature.

The central mechanism by which per capita economic growth occurs in the Solow-Swan model is through increases in the amount of capital per worker, or 'capital deepening.' The associated 'prediction' of the model is that, along transition paths towards a steady state,[12] high per capita output growth would be associated with high investment rates relative to labour force and population growth rates,

reference to Swan's contribution and refer to the model as the Solow model. I have fairly strong personal reasons for not doing so, and will refer to the model as the Solow-Swan growth model.

12 A feature of the model is that steady-state per capita income is constant, irrespective of the savings rate. Thus the steady-state of the model cannot be offered as an explanation of income growth. If the Solow-Swan model is descriptive of reality, therefore, we have been observing non-steady-state trajectories at least since the industrial revolution. The choice of what we mean by 'steady-state' is, of course, largely a matter of definition in any case.

TABLE 1

Ind. var.	Coef. (*t*-stat)	Coef. (*t*-stat)	Coef. (*t*-stat)	Coef. (*t*-stat)
Investment	0.12 (6.74)			0.11 (5.15)
Population growth rate		0.64 (−3.71)		−0.38 (−2.20)
Initial PC output			0.16 (2.06)	−0.14 (−1.94)
Constant	−0.22 (−0.62)	3.27 (8.25)	1.57 (6.48)	0.98 (1.47)
(adj) R^2	0.28	0.11	0.03	0.29

NOTE: Dependent variable = annualized percentage growth rate of per capita real output

which would tend to raise the capital labour ratio. In addition, other things equal, growth rates should be negatively correlated with initial per capita output. This follows because low initial per capita output arises purely from low capital:labour ratios (assuming, in the neoclassical tradition, that all countries have access to the same aggregate production function). If capital labour ratios are low, then the marginal productivity of investment is high, and a given investment rate should give rise to faster growth of per capita output. Thus we should observe convergency in the data, with the poorer countries converging on wealthier countries.

We can 'test' the model in at least two ways. One type of empirical test is to use comparative cross-country regressions. One can simply regress per capita output growth (or a closely related variable) on investment, population (or labour force) growth, and initial per capita output for a cross-section of countries, checking for a good 'fit' and carrying out other specification tests. While some researchers (notably Mankiw, Romer, and Weil 1990) have argued that such exercises are supportive of the basic Solow-Swan growth model, most observers interpret the data as being less than favourable to the model. Table 1 shows a regression of annualized per capita output growth versus investment rate (investment as a percentage of GDP, annualized population growth, and initial (1960) per capita output for 116 countries, along with simple regressions for each of the explanatory variables.

The last column in this regression indicates that investment has a strong positive effect on economic growth that is statistically and economically significant. The point coefficient estimate suggests that an increase of 10 percentage points in the investment to GDP (from, e.g., 10 per cent to 20 per cent) would add just over a full percentage point to annual per capita growth, which is a substantial amount. Population growth has a statistically significant negative effect that is of moderate economic significance. Initial per capita output, while slightly positive in a simple regression, acquires an almost statistically significant negative coefficient (indicating conditional catch-up) once investment and population growth are 'corrected for.' With an adjusted R^2 of 0.29, however, most of the variation in per capita output growth is left unexplained.

Figure 6 is perhaps a more revealing representation of the results of this regression: the 116 countries were ordered by predicted per capita output growth, based on the regression results in table 1. Predicted values are shown by the solid

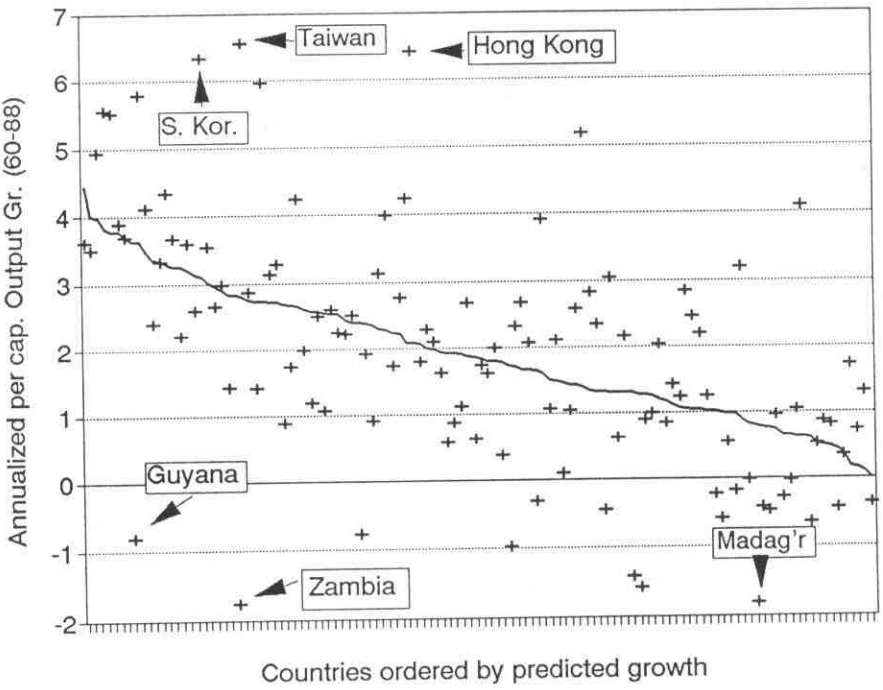

FIGURE 6 Regression of per capita real output growth on investment, population growth, and initial per capita output, actual and predicted values

line; actual values are indicated by plus signs. Thus, for each point the residual (actual minus predicted value) is given by its vertical distance from the solid line. Obviously, there are some pretty substantial outliers. Taiwan, for example, has a predicted annualized growth rate of just under 3 per cent and an actual annualized growth rate of just under 7 per cent. Using growth ratios, the regression 'predicts' that real income in Taiwan would have increased by a factor about 2.5. In fact it grew by a factor of 6. Negative outliers were also rather substantial. Zambia, like Taiwan, had a predicted growth ratio of about 2.5, largely because of a very high investment rate, but an actual growth ratio of 0.6. The residuals are far too large and far too systematic (from a regional point of view) to be satisfactorily explained by the basic Solow-Swan growth model.

I conclude, as have Paul Romer (1989) and many others, that there is a lot left to be explained. The growth rate of the group of fast-growing countries in Asia, now apparently expanded to include China, Indonesia, Malaysia, and Thailand, is far too high to be explained by physical capital accumulation in a traditional neoclassical setting.

A second test is to undertake a growth accounting exercise, looking at the time series for one or more countries and asking if the growth of capital per worker can reasonably account for the growth in output. This type of analysis has been carried out by Solow (1957), Denison (1967), and others for the United States.

The conclusion was that capital accumulation could not satisfactorily account for income growth. The response of Solow and others was to attribute a large part of growth to exogenous technological progress. For example, Solow (1957) concludes that over the period 1909–49, only about 12.5 per cent of U.S. growth in output per worker was due to capital deepening, and 87.5 per cent was attributable to a residual (usually referred to as the 'Solow residual'). Solow assumed that this residual was 'technical change', but it could have been due, at least in part, to other factors as well. Later studies that more carefully account for changes in factor quality (such as Jorgenson et al. 1987 and Maddison 1987) suggest lower but still substantial unexplained growth.

Note that considering technological progress itself affects the interpretation of the regression in table 1. Even if investment statistically 'explained' the data very well, there would still be the question of whether investment represented more physical capital, or whether it represented the replacement of old inferior technologies with new technologies (i.e., not more capital, but different capital). Technological change could lead to higher induced investment and to higher income, without a necessary increase in physical capital per worker. In other words, if investment embodies new technology, the coefficient on investment captures two things: capital accumulation and the effects of technical progress. A coefficient on investment that is 'too high' given what we know about production functions is itself evidence of the importance of technological progress.

IV. ENDOGENOUS GROWTH THEORY

As described in the previous section, the interpretation of recent events that we would draw from the basic Solow-Swan growth model, augmented to include technical change, is that investment and capital deepening are important, but are only a modest part of the economic growth process. Most of the growth in the high-growth economies would be attributed to exogenous technical progress, and most of the enormous variation in economic growth across countries would be attributed to unexplained variations in technological progress and technology transfer.

As Paul Romer (1986) and others have pointed out, 'explaining' growth largely through an exogenous residual that we call technical progress is not very satisfactory. If offers a suggestive label for what we observe (differential technical progress), but it does not explain how these differences in technical progress come about. Thus Romer (1986, 1989, 1990), Aghion and Howitt (1992), Grossman and Helpman (1991), and others have pioneered a second flowering of growth theory which seeks to build into economic growth models a process that endogenously determines technological progress as the outcome of more fundamental firm and market level phenomena. The term 'endogenous growth theory' was coined to describe this new line of research. The term endogenous growth is, of course, a misnomer, at least as a distinguishing characteristic, as are many recently coined terms in economics. (Think of 'rational expectations' or 'perfect equilibrium.') Growth was endogenous in the Solow-Swan model. The distinguishing character-

istic of the new growth theory is not the endogeneity of growth, but the endogeneity of technical progress.

The central conceptual issue underlying the new growth theory concerns the extent to which technological change can usefully be modelled as the product of more basic economic forces. Many writers on technology, particularly within the scientific community and the popular press, see scientific progress as the driving force behind technical progress. Scientific progress, in turn, is viewed as the product of intrinsic human intelligence and curiosity, the internal resources and culture of the scientific community itself, and good luck. Technological change would then be largely independent of factors like market structure, market incentives, etc.

Economists like Schmookler (1966), Schumpeter (1942), and the new generation of growth theorists, however, would take a different view. Their work implies (I believe) that variations in technical progress over time and across countries are at least partly due to variations in market incentives for innovation. Thus, if we want to explain the dramatically higher rate of innovation in the Japanese economy than in (what was) the Soviet Union over the 1960–88 period, we do not focus on whether Japanese scientists were smarter, more capable, more numerous, or better funded than Soviet scientists. We look instead to the incentive structure of the Japanese economy that apparently induced and fostered high levels of innovation, and compare it with the apparent anti-innovation bias of centrally planned economies such as the late Soviet Union.

If we agree, as most economists would, that individual and market-level incentives are important explanatory factors for technical progress, the next problem is the mechanical one of successfully modelling the associated processes. An elegant overview of this problem is provided by Romer (1989), so I will not go through it in detail here. The basic point is that what we know about the R&D and innovation process from the field of industrial organization suggests that it gives rise to fundamental 'non-convexities' in production sets. These non-convexities may arise from increasing returns to scale, externalities in the R&D process, or from the public good nature of 'knowledge' that is bundled with innovation.

Thus the state of technology cannot reasonably be treated simply as an additional factor of production in a neoclassical world. Instead, imperfectly competitive market structures and other 'market imperfections' must be explicitly incorporated into the growth model itself. At the normative level, dealing with these 'non-convexities' leads us to combine neoclassical growth with one of the other major developments of the 1950s: the theory of the second best. (See Lipsey and Lancaster 1957.)

In seeking to incorporate production non-convexities and the associated problems of imperfect competition in a general equilibrium setting, the new growth theory has followed, to a large extent, developments pioneered in international trade theory five or six years earlier by Krugman (1980) and others, especially in the use of particular functional forms for utility (or demand) and production. It turns out that only very special functional forms are tractable in general equilibrium representations of monopolistic competition. It is no accident that Gene Grossman

and Elhanan Helpman, two of the leading researchers in the new international trade theory, were also among the pioneers of the new growth theory. As an aside, it seems that reliance on specific functional forms remains one of the main weaknesses in much of the new growth theory, since these functional forms (normally of the CES type) are far from innocuous abstractions.

The main question for our purposes is whether the new endogenous growth theory is likely to contribute significantly to explaining the facts of comparative economic growth. Given the apparent importance of technology transfer and international economic linkages in the growth process, it seems that the most promising line of research is the rapidly growing literature that embeds endogenous growth models in an explicitly international setting. Aside from Grossman and Helpman (1991), other significant contributions include Rivera-Batiz and Romer (1991), Taylor (1992a, b), and Young (1991). Joint consideration of international integration and endogenous growth raises several important considerations.

Consider the position of a firm in country A, deciding whether to invest in innovation. Suppose that an innovating firm has some period of time (possibly endogenous) during which it can earn temporary monopoly rents from the innovation before it is copied by others and the rents go to zero. In autarky (i.e., if trade barriers are prohibitively high) the firm has only its home market from which to earn temporary rents. If international trade barriers are low, the firm has the entire world market from which to earn rents and will normally face a much greater incentive to innovate, especially if the domestic market is small. Multiplying this effect across many firms and many countries, we can see, as emphasized by Baldwin (1992) and by Taylor (1992b), that trade liberalization can increase the growth rate of the economy. Even modest increases in the growth rate will swamp the 'static' gains from trade liberalization. This is true even when the static gains include, as in Harris (1984) and Cox and Harris (1985), gains from static increasing returns to scale and from pro-competitive effects.

This point has greater significance for puzzles associated with international trade policy than it does for comparative growth. In particular, it can help explain why the apparent gains from trade in Europe following the formation of the European Economic Community and in eastern Asia during the recent past have apparently been much larger than were predicted by conventional static models of the gains from trade. However, while it has been argued that there is a possible correlation between some measures of trade 'openness' and income growth,[13] it is very difficult to explain empirically the divergent patterns of growth that we see on the basis of differences in trade policy. Thus the trade linkages aspect of the growth and trade literature gives us less insight than we might have hoped into why growth rates vary so much across countries.

Another feature of the 'growth and trade' literature is that it emphasizes tech-

13 Syrquin and Chenery (1989) report a positive relationship between 'outward orientation' and economic growth. However, the positive relationship between the openness measure in the Penn World Tables (exports plus imports divided by GDP) and economic growth is weak at best, even when adjusted for country size.

nology transfer: the flow of technical knowledge across international boundaries. This does seem to offer great potential for explaining very high temporary rates of growth as some countries converge on 'best practice' technology. Furthermore, it is possible to design models in which small initial differences between countries may give rise to very different growth trajectories, with some countries developing comparative advantage in the 'high-tech' sectors while others do not. There is, however, a big step to be taken in moving from theoretical models in which divergent growth paths may (or may not) occur and convincing empirical implementations.

V. DEMOGRAPHY AND RESOURCE DEPLETION

In the year 1 AD world population is thought to have been about 300 million, after which it required about 1,700 years to double to 600 million. By contrast, world population doubled from 2.5 billion to 5 billion in the thirty-seven-year period 1950–87 and, at current growth rates, would double again to 10 billion by about 2030. While the growth rate of population has actually fallen since its peak about 1970, the absolute increase in population continues to grow every year, and in 1991 was about 93 million. At present a population the size of Canada's is added to the world every three to four months.

The tremendous increase in population that has taken place since the beginning of the industrial revolution is due in large part to several mechanisms associated with technological progress, particularly improved food availability and nutrition. It is possible, however, that in realizing the benefits of technological progress, there might be a trade-off between the quantity of human life and its quality, especially if human population has reached a level at which it is beginning to impinge significantly on the world's aggregate ecological capacity.

Such concerns have led to renewed interest in the relationship between fertility and growth rates of per capita real income. Early work by Coale and Hoover (1958) and others suggested that high fertility does hamper per capita real income growth. Although some results, including those obtained by Hazledine and Moreland (1977) are consistent with this position, clear empirical support has been hard to obtain. Several surveys, including those of Kelley (1988) and Srinivasan (1988), express ambivalence about the effect of population growth on per capita income growth and suggest that failure to obtain significant effects might be the most striking 'stylized result' from the large body of research on this subject.

There are population optimists, such as Simon (1986) and Boserup (1981) who suggest that population growth aids economic development, largely through induced innovation. A slightly less benign but still optimistic view of population is that there is a natural 'demographic transition' that populations go through as incomes rise, tending to reduce fertility rates and bring population into check well before Malthusian limits are reached.

My interpretation of the evidence, however, is that the potential negative effect of population growth on economic development is of major concern. If we consider figure 5 once again, we observe that there has been a significant slowdown

in African per capita output growth over the 1970–88 period. I believe that this slowdown might be due to resource depletion, especially soil erosion, relative to population growth. Keeping in mind that population in Africa more than doubled over the 1960–88 period and that several African countries already have populations that probably exceed the agricultural carrying capacity of the land (as described in Gorse and Steed 1987), I find it hard to avoid a neo-Malthusian interpretation of events.

There is a certain irony in raising neo-Malthusian concerns in the light of evidence presented here; for it is countries with relatively modest per capita natural resource endowments that have done particularly well in the past thirty years. Indeed, as already mentioned, the development literature of the early 1960s makes a major point of Africa's abundant natural resources and Asia's relative poverty of natural resources. In reality, however, these facts are consistent with a neo-Malthusian interpretation. In Asia's rapidly growing economies, per capita natural resource endowments were fairly low to begin with, and population growth has fallen sharply. As a result, these countries have experienced a relatively small impact on per capita incomes arising from (additional) natural resource congestion. In Africa, on the other hand, population has been growing very rapidly in a situation where per capita natural resource endowments were the main source of wealth, implying strong downward pressure on per capita income growth.

Turning to more formal statistical analysis, Brander and Dowrick (1991) decomposed cross-country growth data into five-year intervals, then used declines in fertility (rather than population growth) as an explanatory variable for income growth, along with investment and initial income. They found strong positive effects of fertility declines on income growth. The results are dominated by the fact that the poorly performing countries of subsahara Africa have had stable or rising birth rates in the range of forty-five to fifty per thousand per year over this period, while the rapidly growing countries of eastern Asia have experienced a dramatic decline in fertility over the 1950–85 period, from annual birth rates in the forty to forty-five per thousand range to birth rates below twenty per thousand.

This could simply be evidence of the demographic transition: higher income leading to lower birth rates. However, the innovation in Brander and Dowrick (1991) is to look carefully at the temporal pattern of fertility and income growth. They find evidence that fertility declines precede income growth gains (and investment increases), suggesting that fertility is a key explanatory variable. They also find evidence that income growth in turn has a negative effect on fertility. Thus fertility, investment, and income growth form an interactive dynamic system. An initial negative shock to fertility can have positive effects on investment and income, leading to a further (induced) decline in fertility, reinforcing income and investment growth until a new (and much happier) steady state is reached.

Much of the benefit of lowered fertility comes from a 'participation' effect. After birth rates fall, at some point the ratio of labour market entrants to new dependent children begins to rise. This tends to increase the overall ratio of productive to dependent population and therefore tends to raise per capita output. However, there

may be subsequent downward pressure on the participation rate when the last cohorts from the high fertility period begin to retire. This effect, however, is very sensitive to the interaction of retirement age and life expectancy. The positive participation effect is transitory, but the timing of lowered fertility can obviously have major long-term effects in reducing the size of the steady-state population and therefore in raising steady-state per capita natural resource availability.

In assessing the ability of demographic effects to explain comparative economic growth it is important to emphasize that the evidence is still less than clear, with results depending on theoretical specification, sample selection, and so on. If demographic effects depend fundamentally on natural resources per capita, however, it is not surprising that resource congestion effects that became visible in the late 1980s, when world population was around 5 billion, might have been insignificant in the 1950s and 1960s, when world population was in the 2.5 to 3 billion range. If so, then such effects may be overwhelming by the time world population reaches 10 billion early in the next century, as current population growth rates would imply. It is also possible, of course, that either income-induced demographic transition or the traditional natural checks on population growth, such as disease and famine, might prevent a population of 10 billion from being reached.

VI. HUMAN CAPITAL AND HUMAN RESOURCES

In trying to explain comparative economic growth, many economists, including Barro (1991), Mankiw et al. (1990), Baumol et al. (1989), and others, have placed considerable emphasis on 'human capital.' At one level, it is obvious that differences in human resources are important in explaining differences in economic performance. This applies whether we are considering differences across countries, across firms, or, for that matter, across universities. For example, if asked why the leading economics departments have higher per capita research productivity than other departments, most of us would say that it is because they have stronger faculty, not because they have more physical capital per faculty member. Similarly, it seems clear that cross-country differences in economic performance are correlated with apparent differences in relevant skills.

It should be emphasized that human capital and economic skills are not the same thing, although some commentators seem to use the terms interchangeably. If they were the same, we would not need the term 'human capital.' The term has content because, as defined by Becker (1975), it refers to the accumulation of skills arising from conscious and costly investments in learning those skills, primarily through education, on-the-job training, and related activities. Thus differences in economic productivity across individuals *might* be the product of differences in human capital. They might, alternatively, be the product of differences in intrinsic ability,[14] differences in religious belief, differences in cultural background, or other

14 There is always considerable controversy over what 'intrinsic' ability might be. As I see the evidence, there is a rapidly growing and quite overwhelming body of evidence that individual

factors, rather than arising from differential investments in human capital. In addition, human capital investments and intrinsic or other differences might interact. Specifically, certain intrinsic differences might make it possible for some people to benefit more than others from a given human capital investment.

In trying to understand comparative economic growth, Mankiw et al. (1990) augment the basic Solow-Swan model with human capital. The measure of human capital they use is the population of secondary school students as a percentage of the working-age population, both averaged over the 1960–85 period. In regressions seeking to explain cross-country variations in per capita income growth over the 1960–85 period, they find the education variable to be highly significant for the 'world' (ninety-eight countries from Mark 4 of the Penn World Table (PWT4)), although not significant within the OECD. It is easy to see why education is significant if we consider the data underlying figure 6. The negative outliers in figure 6 consist largely of subsaharan African countries, most of which have very low values for the education variable, whereas the high outliers tend to have high ratios of secondary school enrolment to working-age population. Thus, adding this education variable to a regression like the one illustrated in figure 6 will give significant explanatory power, although still leaving over half the variation in the data unexplained.

Barro (1991) reports a variety of similar regressions using human capital measures as explanatory variables for growth rates calculated from PWT4. The human capital measures include school enrolment, student-teacher ratios, and literacy rates. Barro (1991) also finds that human capital variables are significant in explaining comparative economic growth. A reasonable conclusion to be drawn from the data analysis on human capital is that even the crude measures of human capital that we have available are correlated with per capita output growth. If we attribute explanatory power to this correlation, we would say that human capital measures seem to explain a modest but significant portion of the total variation of per capita output growth.

There are several concerns one might have in interpreting the human capital results. First of all, we have the same problem as we do with fertility: it is not obvious whether higher education levels are the cause or the consequence of economic growth. If education is in part a consumption good with a positive income elasticity (as seems likely), then, as incomes rise, people will consume more education. Thus we would observe that both income growth and income levels would be positively correlated with educational levels, even if education did little to enhance productive skills. At the very least, regressions of the type described above would overstate the contribution of education (and human capital more generally) to economic growth.

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variations in behaviour, interests, and abilities are due in substantial part to characteristics that are present at birth. Some of these characteristics are genetically transmitted, some are related to the fetal environment, and some are not well understood. Despite this evidence, references to innate differences in ability seem, if anything, to be even less politically acceptable now than they were twenty years ago when the evidence was much more tenuous. For an interesting discussion of individual differences in intelligence see Snyderman and Rothman (1988). See D'Souza (1991) for an interesting analysis of 'political correctness' and its impact on universities.

Second, both higher education levels and better economic performance might be caused by common underlying factors, rather than educational attainment's being the cause of economic performance. At the cross-country level, one piece of evidence suggesting the possible importance of underlying common factors is the very strong regional and even stronger ethnically based clustering of data characteristics. For example, a group of countries in eastern Asia have had rapid growth, high education levels, similar cultural and religious backgrounds, and closely related ethnic backgrounds. In economics we normally attribute nothing to the latter two considerations, but perhaps they play an important role in explaining both economic and educational attainment.

Finally, there is another argument related to human resources that deserves attention. Within any national population there is substantial heterogeneity in economic skills or 'talent.' While some of these talents might be very specific, some are very general and could be applied in many areas. In particular, as emphasized in the literature on 'rent-seeking,' these talents can be applied either to wealth-generating activity or to redistributive (or 'rent-seeking') activity. As suggested by Olson (1982), among others, income growth for a country might depend heavily on how large the rent-seeking sector is relative to the wealth-generating sector. It is perhaps even more important whether highly talented individuals get allocated to the wealth-generating sector or to the redistributive sector.

Thus, for example, one possible reason for the comparative slowdown in U.S. productivity growth (relative to Asia) might be the fact that a relatively large portion of the most talented young people in the United States become lawyers rather than engineers or entrepreneurs. Magee, Brock, and Young (1989) present evidence supporting the idea that U.S. lawyers have, at the margin, a negative impact on real national income. Murphy, Schleifer, and Vishny (1991) use PWT4, augmented by education variables from various sources, to draw inferences about the relative impact of variations in cross-country law and engineering enrolments on per capita output growth. Although their estimations should be regarded as illustrative rather than definitive, they do find that enrolments in law schools have an economically significant negative effect on growth, while university enrolments in engineering have significant positive effects. Thus, while the aggregate accumulation of human capital may be important, it is also important that it be allocated in the right places.

VII. GOVERNMENT INTERVENTION AND ECONOMIC GROWTH

Economists have spent a great deal of time considering the impact of government intervention on economic performance. It would, therefore, be reasonable to consider the possibility that such factors could partially explain cross-country variations in growth.[15] Government interventions could, of course, have an impact on some of the explanatory variables already considered, such as investment, education, fer-

15 The implications of cross-country variations in growth for public policy are certainly important enough to warrant substantial attention even in courses and textbooks on micro-economic policy. Brander (1992) makes a modest step in this direction.

tility, induced innovation, and so on. (See King and Rebelo 1990 for an analysis of how public policies may affect growth through their effect on human capital and induced innovation.) It may be possible, however, to observe the effects of government intervention directly in cross-country data.

Perhaps the first level of government intervention to consider is the highest level:[16] the simple contrast between market-based and centrally planned systems. Unfortunately, while there is now general acceptance of the idea that centrally planned socialism or communism is a 'failed' experiment, we do not have very systematic data on this apparent economic failure. In moving from PWT4 to PWT5, Summers and Heston (1991) removed most of the centrally planned economies from the data set because of increasingly obvious biases and errors in the associated data. However, the Income Comparison Project that underlies the Penn World Table is doing a systematic recalculation of national income for the former centrally planned economies, so data for these countries should be available soon.

I will refrain from commenting in detail on the smattering of evidence from those communist countries that are in PWT5, although the striking Chinese experience has already been discussed. The absence of systematic data on communist economies does not, however, diminish the impressive qualitative comparison between centrally planned and market-based matched pairs of otherwise similar countries. Such pairs include the former West and East Germany, North and South Korea, and Burma (Myanmar) and Thailand, not to mention the general comparison between western and eastern Europe, or between the market and centrally planned economies of eastern Asia. All this evidence points clearly to the very substantial superiority of market-based economies over centrally planned economies in producing per capita economic growth.

Another 'high-level' question concerns the effects of political democracy or political freedom on economic growth. I have little to contribute here, except to alert the reader to the existence of some interesting research in the area, much of which is cited in Sirowy and Inkeles (1990). In very recent work Helliwell (1992) confirms the basic cross-section result that high levels of per capita income are associated with high levels of political freedom and with democratic institutions. Helliwell then revisits the question of causal direction: do high incomes lead to political freedom or, conversely, does political freedom lead to high incomes, or is some other relationship involved? He finds tentative support for a causal link from high incomes to political freedom and for a slight negative effect of political freedom on economic growth.[17] My interpretation is that political freedom appears much like a luxury consumption good in the strict sense: as societies (and individuals) become wealthier, they seem willing to spend an increasing fraction of

16 One might argue that the most obvious 'political' effects on growth are the negative effects of wars and revolutions. This does partially explain some of the more dramatic poor performances in recent data.

17 In closely related work Vanassay and Spindler (1992) find that constitutionally guaranteed freedoms do not seem to contribute positively to economic performance. Ethiopia, for example, has much stronger such guarantees than Japan. As most economists would expect, prosperity cannot be achieved simply by having governments proclaim it.

their potential income on it. This opinion is, however, very speculative, since it is difficult to say anything with confidence about the contribution of variations in political freedom to variations in economic growth.

As for the effects of more specific government policies on economic growth, a substantial fraction of the total body of economic research could be regarded as addressing that question in one way or another. The body of research that specifically examines cross-country variations in government activity using consistent cross-country data, however, is fairly small and is very closely related to much of the work already cited. Two particular papers of interest are Kormendi and Mequire (1985) and Grier and Tullock (1989). Both papers add additional explanatory variables related to macroeconomic policy to regression equations of the type reported in table 1. The main findings are that both high levels of government spending relative to GDP and high levels of inflation are negatively correlated with real income growth.

Finally, we sometimes forget that what we take as a 'non-interventionist' ideal actual requires a good deal of government intervention. As emphasized in the 'property rights' literature in economics, what separates a working market system from anarchy is a well-defined legal structure of property rights, contract enforcement, and economic freedoms. In the absence of such a structure, rampant rent-seeking through theft and violence and highly inefficient restraints on trade become the norm. De Soto (1990) argues persuasively that a large cause of Peru's poor economic performance lies in the government's inability to provide a neutral and efficient contract enforcement, becoming instead the principal rent-seeking mechanism in the economy.

VIII. CONCLUDING REMARKS

This paper argues that the most compelling economic fact of the modern era is the dramatic and unprecedented variation in economic growth across countries and regions. In addition to describing some of the relevant stylized facts, I have also reviewed the major classes of economic explanation for them. It is clear that several lines of enquiry, including endogenous technological change, demographic change, differences in human resources, and the direct effects of government intervention offer important clues about the comparative growth process. It should also be clear, however, that our understanding of the causes of growth is still rather fragile, as every decade brings new surprises. While many economists are lining up to give advice to the new governments in eastern Europe, I am not sure that expert advice on growth theory would, at this stage, provide much value added beyond the basic insights obtained from Adam Smith and David Ricardo.

One question that has not been addressed directly in the paper concerns why very rapid rates of growth and corresponding high variations in economic growth have occurred only now, in the latter twentieth century, rather than before. There are three things that are fundamentally different about the current period. First, recent improvements in communication and transportation between countries seem to

have magnified whatever fundamental differences give rise to differential economic performance. More specifically, the potential speed of technology transfer across countries is higher than it has ever been, which gives more room for variation in economic performance than ever before. Second, continuing technological progress has greatly expanded the difference between what 'raw labour' and sophisticated labour can accomplish, possibly magnifying the effect of differences in certain productive skills.

Finally, I believe we have recently entered a period in which natural resource depletion and congestion are becoming economically important. While this would tend to reduce aggregate growth rates (as I believe is happening), it also tends to increase the effect of variations in fertility on economic performance. Putting the point more directly, the countries that continue to have very high fertility and population growth rates may face increasingly poor relative economic prospects, checked from below only by the Malthusian limit. This limit seems already to be close in parts of Africa.

In the introduction I proposed three alternatives to variation in comparative economic growth as the dominant economic fact of our time: the victory of market capitalism over central planning, global resource depletion, and the internationalization of the world economy. We have now come full circle; for it is now clear that all three of these phenomena are closely connected to the pattern of comparative economic growth. The variation of comparative growth remains, however, the central and dominant economic event to be explained.

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