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ON THE MECHANICS OF ECONOMIC DEVELOPMENT*

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This paper considers the prospects for constructing a neoclassical theory of growth and international trade that is consistent with some of the main features of economic development. Three models are considered and compared to evidence: a model emphasizing physical capital accumulation and technological change, a model emphasizing human capital accumulation through schooling, and a model emphasizing specialized human capital accumulation through learning-by-doing.

1. Introduction

By the problem of economic development I mean simply the problem of accounting for the observed pattern, across countries and across time, in levels and rates of growth of per capita income. This may seem too narrow a definition, and perhaps it is, but thinking about income patterns will necessarily involve us in thinking about many other aspects of societies too, so I would suggest that we withhold judgment on the scope of this definition until we have a clearer idea of where it leads us.

The main features of levels and rates of growth of national incomes are well enough known to all of us, but I want to begin with a few numbers, so as to set a quantitative tone and to keep us from getting mired in the wrong kind of details. Unless I say otherwise, all figures are from the World Bank's *World Development Report* of 1983.

The diversity across countries in measured per capita income levels is literally too great to be believed. Compared to the 1980 average for what the World Bank calls the 'industrial market economies' (Ireland up through Switzerland) of U.S. $10,000, India's per capita income is $240, Haiti's is $270,

*This paper was originally written for the Marshall Lectures, given at Cambridge University in 1985. I am very grateful to the Cambridge faculty for this honor, and also for the invitation's long lead time, which gave me the opportunity to think through a new topic with the stimulus of so distinguished an audience in prospect. Since then, versions of this lecture have been given as the David Horowitz Lectures in Israel, the W.A. Mackintosh Lecture at Queens University, the Carl Snyder Memorial Lecture at the University of California at Santa Barbara, the Chung-Hua Lecture in Taipei, the Nancy Schwartz Lecture at Northwestern University, and the Lionel McKenzie Lecture at the University of Rochester. I have also based several seminars on various parts of this material.

and so on for the rest of the very poorest countries. This is a difference of a factor of 40 in living standards! These latter figures are too low to sustain life in, say, England or the United States, so they cannot be taken at face value and I will avoid hanging too much on their exact magnitudes. But I do not think anyone will argue that there is not enormous diversity in living standards.[1]

Rates of growth of real per capita GNP are also diverse, even over sustained periods. For 1960–80 we observe, for example: India, 1.4% per year; Egypt, 3.4%; South Korea, 7.0%; Japan, 7.1%; the United States, 2.3%; the industrial economies averaged 3.6%. To obtain from growth rates the number of years it takes for incomes to double, divide these numbers into 69 (the log of 2 times 100). Then Indian incomes will double every 50 years; Korean every 10. An Indian will, on average, be twice as well off as his grandfather; a Korean 32 times. These differences are at least as striking as differences in income levels, and in some respects more trustworthy, since within-country income comparisons are easier to draw than across-country comparisons.

I have not calculated a correlation across countries between income levels and rates of growth, but it would not be far from zero. (The poorest countries tend to have the lowest growth; the wealthiest next; the 'middle-income' countries highest.) The generalizations that strike the eye have to do with variability within these broad groups: the rich countries show little diversity (Japan excepted – else it would not have been classed as a rich country in 1980 at all). Within the poor countries (low and middle income) there is enormous variability.[2]

Within the advanced countries, growth rates tend to be very stable over long periods of time, provided one averages over periods long enough to eliminate business-cycle effects (or corrects for short-term fluctuations in some other way). For poorer countries, however, there are many examples of sudden, large changes in growth rates, both up and down. Some of these changes are no doubt due to political or military disruption: Angola's total GDP growth fell from 4.8 in the 60s to −9.2 in the 70s; Iran's fell from 11.3 to 2.5, comparing the same two periods. I do not think we need to look to economic theory for an account of either of *these* declines. There are also some striking examples

[1] The income estimates reported in Summers and Heston (1984) are more satisfactory than those in the World Development Reports. In 1975 U.S. dollars, these authors estimate 1980 U.S. real GDP per capita at $8000, and for the industrialized economies as a group, $5900. The comparable figures for India and Haiti are $460 and $500, respectively. Income differences of a factor of 16 are certainly smaller, and I think more accurate, than a factor of 40, but I think they are still fairly described as exhibiting 'enormous diversity'.

[2] Baumol (1986) summarizes evidence, mainly from Maddison (1982) indicating apparent convergence during this century to a common path of the income levels of the wealthiest countries. But De Long (1987) shows that this effect is entirely due to 'selection bias': If one examines the countries with the highest income levels at the *beginning* of the century (as opposed to currently, as in Maddison's 'sample') the data show apparent *divergence*!

of sharp increases in growth rates. The four East Asian 'miracles' of South Korea, Taiwan, Hong Kong and Singapore are the most familiar: for the 1960–80 period, per capita income in these economies grew at rates of 7.0, 6.5, 6.8 and 7.5, respectively, compared to much lower rates in the 1950's and earlier.[3,4] Between the 60s and the 70s, Indonesia's GDP growth increased from 3.9 to 7.5; Syria's from 4.6 to 10.0.

I do not see how one can look at figures like these without seeing them as representing *possibilities*. Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia's or Egypt's? If so, *what*, exactly? If not, what is it about the 'nature of India' that makes it so? The consequences for human welfare involved in questions like these are simply staggering: Once one starts to think about them, it is hard to think about anything else.

This is what we need a theory of economic development *for*: to provide some kind of framework for organizing facts like these, for judging which represent opportunities and which necessities. But the term 'theory' is used in so many different ways, even within economics, that if I do not clarify what I mean by it early on, the gap between what I think I am saying and what you think you are hearing will grow too wide for us to have a serious discussion. I prefer to use the term 'theory' in a very narrow sense, to refer to an explicit dynamic system, something that can be put on a computer and *run*. This is what I mean by the 'mechanics' of economic development – the construction of a mechanical, artificial world, populated by the interacting robots that economics typically studies, that is capable of exhibiting behavior the gross features of which resemble those of the actual world that I have just described. My lectures will be occupied with one such construction, and it will take some work: It is easy to set out models of economic growth based on reasonable-looking axioms that predict the cessation of growth in a few decades, or that predict the rapid convergence of the living standards of different economies to a common level, or that otherwise produce logically possible outcomes that bear no resemblance to the outcomes produced by actual economic systems. On the other hand, there is no doubt that there must be mechanics other than the ones I will describe that would fit the facts about as well as mine. This is why I have titled the lectures '*On* the Mechanics ...' rather than simply '*The* Mechanics of Economic Development'. At some point, then, the study of development will need to involve working out the implications of competing theories for data other than those they were constructed to fit, and testing these implications against observation. But this is getting far ahead of the

[3]The World Bank no longer transmits data for Taiwan. The figure 6.5 in the text is from Harberger (1984, table 1, p. 9).

[4]According to Heston and Summers (1984), Taiwan's per-capita GDP growth rate in the 1950s was 3.6. South Korea's was 1.7 from 1953 to 1960.

story I have to tell, which will involve leaving many important questions open even at the purely theoretical level and will touch upon questions of empirical testing hardly at all.

My plan is as follows. I will begin with an application of a now-standard neoclassical model to the study of twentieth century U.S. growth, closely following the work of Robert Solow, Edward Denison and many others. I will then ask, somewhat unfairly, whether this model *as it stands* is an adequate model of economic development, concluding that it is not. Next, I will consider two adaptations of this standard model to include the effects of human capital accumulation. The first retains the one-sector character of the original model and focuses on the interaction of physical and human capital accumulation. The second examines a two-good system that admits specialized human capital of different kinds and offers interesting possibilities for the interaction of trade and development. Finally, I will turn to a discussion of what has been arrived at and of what is yet to be done.

In general, I will be focusing on various aspects of what economists, using the term very broadly, call the 'technology'. I will be abstracting altogether from the economics of demography, taking population growth as a given throughout. This is a serious omission, for which I can only offer the excuse that a serious discussion of demographic issues would be at least as difficult as the issues I will be discussing and I have neither the time nor the knowledge to do both. I hope the interactions between these topics are not such that they cannot usefully be considered separately, at least in a preliminary way.[5]

I will also be abstracting from all monetary matters, treating all exchange as though it involved goods-for-goods. In general, I believe that the importance of financial matters is very badly over-stressed in popular and even much professional discussion and so am not inclined to be apologetic for going to the other extreme. Yet insofar as the development of financial institutions is a limiting factor in development more generally conceived I will be falsifying the picture, and I have no clear idea as to how badly. But one cannot theorize about everything at once. I had better get on with what I do have to say.

2. Neoclassical growth theory: Review

The example, or model, of a successful theory that I will try to build on is the theory of economic growth that Robert Solow and Edward Denison developed and applied to twentieth century U.S. experience. This theory will serve as a basis for further discussion in three ways: as an example of the *form* that I believe useful aggregative theories must take, as an opportunity to

[5] Becker and Barro (1985) is the first attempt known to me to analyze fertility and capital accumulation decisions *simultaneously* within a general equilibrium framework. Tamura (1986) contains further results along this line.

that 'growth-increasing' and 'welfare-improving' policies will necessarily coincide, but they certainly might.

My objective in this section has been to offer one example of a theoretical model in which rates of growth differ across countries, and not to offer policy advice. The case for infant industry protection based on external effects that this model formalizes is the classic one, and it does not become either more or less valid, empirically, by being embedded in a slightly new framework. But is it possible, I wonder, to account for the large cross-country differences in growth rates that we observe in a theoretical model that does *not* involve external effects of the sort I have postulated here? I have not seen it done.

6. Cities and growth

My concern to this point has been almost exclusively with the aggregate mechanics of economic development, and I am afraid the discussion in these lectures will not get much beyond these mechanics. But I believe a successful theory of development (or of anything else) has to involve more than aggregative modeling, and I would like both to explain what I mean by this and to indicate where one might look to extend the analysis to a deeper and more productive level.

The engine of growth in the models of sections 4 and 5 is *human capital.* Within the context of these two models, human capital is simply an unobservable magnitude or force, with certain assumed properties, that I have postulated in order to account for some observed features of aggregative behavior. If these features of behavior were *all* of the observable consequences of the idea of human capital, then I think it would make little difference if we simply re-named this force, say, the Protestant ethic or the Spirit of History or just 'factor X'. After all, we can no more directly measure the amount of human capital a society has, or the rate at which it is growing, than we can measure the degree to which a society is imbued with the Protestant ethic.

But this is *not* all we know about human capital. This same force, admittedly unobservable, has also been used to account for a vast number of phenomena involving the way people allocate their time, the way individuals' earnings evolve over their lifetimes, aspects of the formation, maintenance and dissolution of relationships within families, firms and other organizations, and so on. The idea of human capital may have seemed ethereal when it was first introduced – at least, it did to me – but after two decades of research applications of human capital theory we have learned to 'see' it in a wide variety of phenomena, just as meteorology has taught us to 'see' the advent of a warm front in a bank of clouds or 'feel' it in the mugginess of the air.

Indeed, for me the development of the theory of human capital has very much altered the way I think about physical capital. We can, after all, no more directly measure a society's holdings of physical capital than we can its human

capital. The fiction of 'counting machines' is helpful in certain abstract contexts but not at all operational or useful in actual economies – even primitive ones. If this was the issue in the famous 'two Cambridges' controversy, then it has long since been resolved in favor of this side of the Atlantic.[17] Physical capital, too, is best viewed as a force, not directly observable, that we postulate in order to account in a unified way for certain things we *can* observe: that goods are produced that yield no immediate benefit to consumers, that the production of these goods enhances labor productivity in future periods, and so on.

The fact that the postulates of both human and physical capital have many observable implications outside the contexts of aggregate models is important in specific, quantitative ways, in addition to simply giving aggregative theorists a sense of having 'microeconomic foundations'. For example, in my application of a human capital model to U.S. aggregative figures, I matched the U.S. observations to the predictions of a competitive model (as opposed to an efficient one) in spite of the fact that education, in the U.S., involves vast government intervention and is obviously not a competitive industry in any descriptive sense. Why not instead identify the observed paths with the model's efficient trajectories? The aggregative data have *no* ability to discriminate between these two hypotheses, so this choice would have yielded as good a 'fit' as the one I made. At this point, I appealed to the observation that most education subsidies are infra-marginal from the individual's point of view. This observation could stand considerable refinement before it could really settle this particular issue, but the point is that aggregate models based on constructs that have implications for data *other* than aggregates – models with 'microeconomic foundations' if you like – permit us to bring evidence to bear on questions of aggregative importance that cannot be resolved with aggregate theory and observations alone. Without the ability to do this, we can do little more than extrapolate past trends into the future, and then be caught by surprise every time one of these trends changes.

The particular aggregate models I have set out utilize the idea of human capital quite centrally, but assign a central role as well to what I have been calling the *external effects* of human capital. This latter force is, it seems to me, on a quite different footing from the idea of human capital generally: The twenty years of research I have referred to earlier is almost exclusively concerned with the *internal* effects of human capital, or with investments in human capital the returns to which accrue to the individual (or his immediate family). If it is this research that permits us to 'see' human capital, then the external effects of this capital must be viewed as remaining largely invisible, or visible at the aggregative level only. For example, in section 4 I arrived at an estimate of $\gamma = 0.4$ for the elasticity of U.S. output with respect to the external effects of human capital on production. Does this seem a plausible number?

[17] That is, the English side.

Or, putting the question in a better way: Is $\gamma = 0.4$ consistent with other evidence? But *what* other evidence? I do not know the answer to this question, but it is so central that I want to spend some time thinking about where the answer may be found. In doing so, I will be following very closely the lead of Jane Jacobs, whose remarkable book *The Economy of Cities* (1969) seems to me mainly and convincingly concerned (though she does not use this terminology) with the external effects of human capital.

I have been concerned with modeling the economic growth of *nations*, considered either singly or as linked through trade. In part, this was a response to the form of the observations I cited at the beginning: Most of our data come in the form of national time series, so 'fitting the facts' is taken to mean fitting national summary facts. For considering effects of changes in policies the nation is again the natural unit, for the most important fiscal and commercial policies are national and affect national economies in a uniform way. But from the viewpoint of a *technology* – like (11) – through which the average skill level of a group of people is assumed to affect the productivity of each individual within the group, a *national* economy is a completely arbitrary unit to consider. Surely if Puerto Rico were to become the fifty-first state this would not, by itself, alter the productivity of the people now located in Puerto Rico, even though it would sharply increase the average level of human capital of those politically defined as their fellow citizens. The external effects that the term h_a^{γ} in (11) is intended to capture have to do with the influences people have on the productivity of others, so the *scope* of such effects must have to do with the ways various groups of people interact, which may be affected by political boundaries but are certainly an entirely different matter conceptually.

Once this question of the scope of external effects is raised, it is clear that it cannot have a single correct answer. Many such effects can be internalized within small groups of people – firms or families. By dealing with an infinitely-lived family as a typical agent, I have assumed that such effects are dealt with at the non-market level and so create no gap between private and social returns. At the other extreme, basic discoveries that immediately become common property – the development of a new mathematical result say – are human capital in the sense that they arise from resources allocated to such discoveries that could instead have been used to produce current consumption, but to most countries as well as to most individual agents they appear 'exogenous' and would be better modelled as $A(t)$ in section 2 than as $h_a(t)$ in section 4.

If it were easy to classify most external productivity effects as either global in scope or as so localized as to be internalizable at the level of the family or the firm, then I think a model that incorporated internal human capital effects only plus other effects treated as exogenous technical change would be adequate. Such a model would fit time series from advanced countries about as well as any I have advanced, being an intermediate model to those I discussed in sections 2 and 4, which were in turn not distinguishable on such data alone.

Such a model would, I think, have difficulty reconciling observed pressures for immigration with the absence of equivalent capital flows, but perhaps this anomaly could be accounted for in some other way.

But we *know* from ordinary experience that there are group interactions that are central to individual productivity and that involve groups larger than the immediate family and smaller than the human race as a whole. Most of what we know we learn from other people. We pay tuition to a few of these teachers, either directly or indirectly by accepting lower pay so we can hand around them, but most of it we get for free, and often in ways that are mutual – without a distinction between student and teacher. Certainly in our own profession, the benefits of colleagues from whom we hope to learn are tangible enough to lead us to spend a considerable fraction of our time fighting over who they shall be, and another fraction travelling to talk with those we wish we could have as colleagues but cannot. We know this kind of external effect is common to all the arts and sciences – the 'creative professions'. All of intellectual history is the history of such effects.

But, as Jacobs has rightly emphasized and illustrated with hundreds of concrete examples, much of economic life is 'creative' in much the same way as is 'art' and 'science'. New York City's garment district, financial district, diamond district, advertising district and many more are as much intellectual centers as is Columbia or New York University. The specific ideas exchanged in these centers differ, of course, from those exchanged in academic circles, but the process is much the same. To an outsider, it even *looks* the same: A collection of people doing pretty much the same thing, each emphasizing his own originality and uniqueness.

Considerations such as these may convince one of the existence of external human capital, and even that it is an important element in the growth of knowledge. But they do not easily lend themselves to quantification. Here again I find Jacobs's work highly suggestive. Her emphasis on the role of cities in economic growth stems from the observation that a city, economically, is like the nucleus of an atom: If we postulate only the usual list of economic forces, cities should fly apart. The theory of production contains nothing to hold a city together. A city is simply a collection of factors of production – capital, people and land – and land is always far cheaper outside cities than inside. Why don't capital and people move outside, combining themselves with cheaper land and thereby increasing profits? Of course, people like to live near shopping and shops need to be located near their customers, but circular considerations of this kind explain only shopping centers, not cities. Cities are centered on wholesale trade and primary producers, and a theory that accounts for their existence has to explain why these producers are apparently choosing high rather than low cost modes of operation.

It seems to me that the 'force' we need to postulate account for the central role of cities in economic life is of exactly the same character as the 'external human capital' I have postulated as a force to account for certain features of

aggregative development. If so, then land rents should provide an indirect measure of this force, in much the same way that schooling-induced earnings differentials provide a measure of the productive effects of internal human capital. It would require a much more detailed theory of the external effects of human capital than anything I have provided to make use of the information in urban land rents (just as one needs a more detailed theory of human capital than that in section 4 to utilize the information in earnings data), but the general logic is the same in the two cases. What can people be paying Manhattan or downtown Chicago rents *for*, if not for being near other people?

7. Conclusions

My aim, as I said at the beginning of these lectures, has been to try to find what I called 'mechanics' suitable for the study of economic development: that is, a system of differential equations the solution to which imitates some of the main features of the economic behavior we observe in the world economy. This enterprise has been taken about as far as I am able to take it, at present, so I will stop and try to sum up what the main features of these mechanics are and the sense in which they conform to what we observe.

The model that I think is central was developed in section 4. It is a system with a given rate of population growth but which is acted on by no other outside or exogenous forces. There are two kinds of capital, or state variables, in the system: physical capital that is accumulated and utilized in production under a familiar neoclassical technology, and human capital that enhances the productivity or both labor and physical capital, and that is accumulated according to a 'law' having the crucial property that a constant level of effort produces a constant growth rate of the stock, independent of the level already attained.

The dynamics of this system, viewed as a single, closed economy, are as follows. Asymptotically, the marginal product of physical capital tends to a constant, given essentially by the rate of time preference. This fact, which with one kind of capital defines the long-run stock of that capital, in the two-capital model of section 4 defines a curve in the 'physical capital–human capital plane'. The system will converge to this curve from any initial configuration of capital stocks, but the particular point to which it converges will depend on initial conditions. Economies that are initially poor will remain poor, relatively, though their long-run rate of income growth will be the same as that of initially (and permanently) wealthier economies. A world consisting of such economies, then, each operating autarchically, would exhibit uniform rates of growth across countries and would maintain a perfectly stable distribution of income and wealth over time.

If trade in capital goods is introduced into this model world economy, with labor assumed immobile, there will be no tendency to trade, which is to say no

systematic tendency for borrowing and lending relationships to emerge between rich and poor countries. Put another way, the long-run relationship between the two kinds of capital that holds in each country implies the same marginal productivity of physical capital, no matter what the level of capital that has been accumulated. The picture I have given for a world of closed economies thus carries over without change to a world with free trade in capital goods.

If labor mobility is introduced, everything hinges on whether the effects of human capital are internal – affecting the productivity of its 'owner' only – or whether they have external benefits that spill over from one person to another. In the latter case, and only in the latter case, the wage rate of labor at any given skill level will increase with the wealth of the country in which he is employed. Then if labor can move, it will move, flowing in general from poor countries to wealthy ones.

The model I have described fits the evidence of the last century for the U.S. economy as well as the now standard neoclassical model of Solow and Denison, which is to say, remarkably well. This is of course no accident, for the mechanics I have been developing have been modeled as closely as possible on theirs. It also fits, about as well, what seem to me the main features of the world economy: very wide diversity in income levels across countries, sustained growth in per-capita incomes at all income levels (though not, of course, in each country at each income level), and the absence of any marked tendency for growth rates to differ systematically at different levels of income. The model is also consistent with the enormous pressures for immigration that we observe in the world, even with its extreme assumptions that assign no importance to differences in endowments of natural resources and that permit perfectly free trade in capital and consumption goods. As long as people at each skill level are more productive in high human capital environments, such pressures are predicted to exist and nothing but the movement of people can relieve them.

Though the model of section 4 seems capable of accounting for *average* rates of growth, it contains no forces to account for diversity over countries or over time within a country (except for arbitrary shifts in tastes or technology). Section 5 develops a two-commodity elaboration of this model that offers more possibilities. In this set-up, human capital accumulation is taken to be specific to the production of particular goods, and is acquired on-the-job or through learning-by-doing. If different goods are taken to have different potentials for human capital growth, then the same considerations of comparative advantage that determine which goods get produced where will also dictate each country's rate of human capital growth. The model thus admits the possibility of wide and sustained differences in growth rates across countries, differences that one would not expect to be systematically linked to each country's initial capital *levels*.

With a fixed set of goods, which was the only case I considered, this account of cross-country differences does not leave room for within-country changes in growth rates. The comparative advantages that dictate a country's initial production mix will simply be intensified over time by human capital accumulation. But I conjecture that a more satisfactory treatment of product-specific learning would involve modeling the continuous introduction of new goods, with learning potentials on any particular good declining with the amount produced. There is no doubt that we observe this kind of effect occuring in reality on particular product lines. If it could be captured in a tractable aggregative model, this would introduce a factor continuously shaking up an existing pattern of comparative advantages, and offer some interesting possibilities for shifts over time in a country's growth rate, within the same general equilibrium framework used in section 5.

If such an analysis of trade-related shifts in growth rates should turn out to possible, this would be interesting, because the dramatic recent development success stories, the 'growth miracles' of Korea, Taiwan, Hong Kong and Singapore (not to mention the ongoing miracle of Japan) have all been associated with increases in exports, and more suggestively still, with exports of goods not formerly produced in these countries. There is surely no strain in thinking that a model stressing the effects of learning-by-doing is likely to shed light on these events.

A successful theory of economic development clearly needs, in the first place, mechanics that are consistent with sustained growth and with sustained diversity in income levels. This was the objective of section 4. But there is no one pattern of growth to which all economies conform, so a useful theory needs also to capture some forces for change in these patterns, and a mechanics that permits these forces to operate. This is a harder task, certainly not carried out in the analysis I have worked through, but I think the analysis of section 5 is a promising beginning.

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