

Relevance of Growth Models to Development Planning

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Growth models can be viewed in three distinct ways. Firstly, they can be viewed as "analytical filing" devices. Secondly, they can be viewed as casual schemes of explanation. Thirdly, they can be regarded as an example of "instrumental inference". From the point of view of development planning, the first and the third uses are very important. It is argued in the paper that from these points of view, they do serve useful purposes. This is true despite the existence of numerous deficiencies from which currently existing models suffer. This argument is supported in the paper with the help of illustrations from the existing literature on growth models.

I

From 1848 to 1948, a period of one hundred years, there was little explicit concern with 'growth models' even after allowing for a very informal definition of what constitutes a model. We are, of course, excluding the very important work that was done by Marx, especially in the second volume of *The Capital*, which was published in an edited form by Engels. This is because even amongst Marxists, the second volume did not exercise as much influence as it should have exercised, partly, no doubt, because of its somewhat formal and disjointed character. They were, of course, completely ignored by prominent critics of Marx such as Bohm-Bawerk.

We may be inclined to include Marshall amongst the precursors of what is known these days as the "neoclassical" model of growth. This has some justification inasmuch as Marshall did devote some attention to the problem of growth in his *Principles*, and as the recent edition of Marshall's early works by Whitaker [17; pp. 305-316] shows, Marshall had developed a formal model of growth as early as 1881, which, although insufficiently analyzed, did contain many features which are treated as important today, notably his treatment of an aggregate production function and measurement of labour in efficiency units. But Marshall failed to achieve any integration between his theory of value and his theory of growth. Hence the treatment of the central issues of growth in his *Principles* was informal and there was little or no attempt on his part to investigate the effect of growth as a *continuing process* on issues such as the distribution of incomes or questions of incidence of taxes like the ones that preoccupied Ricardo or Mill.

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We are, therefore, not without justification if we only mention two major efforts during this period outside the Marxist tradition which can be described as significant from the point of view of the developments that took place during the last thirty years or so. These exceptions pertain to Cassel's attempt to describe the properties of a uniformly progressing economy [1] and Harrod's first essay on dynamic theory [6] which appeared in 1939. Of these two efforts, Cassel's was doubtless a very preliminary one and nothing by way of a theorem came out of Cassel's analysis. But Harrod's was a very different matter. However, even here we must recall that Harrod's primary preoccupation during these years was with the problem of "Trade Cycle" and, as he himself wrote in the late Fifties, "it was the effort" to reduce the doctrines of his book on "The Trade Cycle" into better order which led him to the formulation of his famous "growth equation" [7]. Thus Harrod's objective was not one of constructing a causal theory of growth but that of trying to ascertain the necessary relations that must pertain to elements in a steadily growing economy. His main achievement was not merely to show that a certain precise relation did in fact hold but also to demonstrate that such a path of growth was surrounded by centrifugal forces. This is the famous 'instability principle' of Harrod.

During the early post-war period, interest in Harrod's work revived partly because of the further work done by Harrod himself and partly because of the work that was done by Domar. There are some significant differences between Domar's work and Harrod's work which it would be out of place to discuss here. What is important, however, is that they were both extensions of Keynes's work which in itself was static [13].

Now Keynes himself was not interested in policy problems facing developing countries. His primary policy concern was to show what needed to be done to reach full employment in mature capitalist countries. Domar hit on his equation by trying to work out the rate at which investment will have to increase if full employment were to obtain after allowing for the effect of investment on productivity along with its demand-creating effect which Keynes had earlier emphasized.

But when it came to developing countries, the nature of unemployment problem was recognizably a very different one. How did it come about that the same model of growth was found to be useful in this vastly different context? I believe that there were two very distinct reasons for this "migration of ideas". One reason is that to talk about growing economies, one must use a certain language of discourse. It is not merely the relationships between absolute levels of variables which are important but the relationships between rates of growth are also important. Harrod and Domar had provided the profession with such a language which was valid no matter whether one was talking about advanced or early stages of development. They had also provided the profession with certain handy tools such as the 'capital-output' ratios which tried to take into account the "time structure of

production", which could be disaggregated by sectors to give us more aid in planning investment.¹

The other reason was that the hybrid, called the "Harrod-Domar" model, looked to some economists like a valid theory of growth at least on a first level of approximation. It seemed to give policy conclusions which fitted in with the commonsense of the profession. That a higher rate of savings was a good thing seemed justified: so also did the idea that a lower capital-output ratio was more helpful in triggering off growth. For a 'capital-scarce', 'labour-abundant country', these prescriptions had a compelling quality, at least on the surface.

Discussion during the last two decades has clearly indicated that there is little warrant for treating the Harrod-Domar model as a causal theory of growth, even for labour-abundant countries. Some have questioned it for the alleged lack of substitution between 'capital' and 'labour', while others have rejected the concept of an economy-wide production function involving homogeneous 'capital' and homogeneous 'labour'. It has also been questioned whether it is proper to talk about the savings ratio as if it were independent of the capital-output ratio. Thus, the argument for choosing capital-light techniques which would seem to follow from this model has been questioned by others who would prefer capital-rich techniques on the ground that this implies a higher rate of savings and thus, on a close analysis, is more beneficial from the growth point of view.

The only conclusion that one can draw from this intensive debate is that we do not possess as yet a theoretically coherent and empirically well-grounded causally adequate model of growth. What we have got from these growth models constitutes what Hicks calls a dynamic method of analysis [8, Chapter 1].

From this, are we justified in concluding that growth models are not relevant for development planning? If we are, this would be a rather unfortunate state of affairs, at least for two major reasons. Firstly, the argument for development planning arose in the first instance from the perception that market failures were a fairly pervasive feature of developing economies. Nothing by way of refinement in the general equilibrium analysis that has taken place in the last twenty years would help to establish the claim that there are reasons to believe that markets function satisfactorily in relation to crucial areas of the economy, such as labour, foreign exchange and capital. Especially in regard to capital markets, doubts are very strong indeed, on both theoretical and empirical grounds [3].

Decisions pertaining to the determination of the volume and composition of investment may, therefore, have to be taken by non-market processes even if one were to rely on the market for implementation. A development plan is to be regarded as a device for answering these problems and the need to get plans better-formulated persists as before. It may, of course, be true that in regard to problems of plan imple-

¹ On the usefulness and limitation of "Capital-output ratios" as forecasting devices much has been written. Here we are concerned with its analytic contribution. On this, it is pertinent to refer to Hicks [8, Part II, Chapter XIV].

mentation, the market mechanism may have a greater role to play than was often assumed earlier. However, to treat the market as an instrument of plan fulfilment is a different thing from treating the 'market system' as the sole provider of all relevant economic signals including choices between present and future consumptions or other related issues.

The absence of a causally adequate model of growth, while regrettable from many points of view, does not, however, leave us with a situation in which we have to fall back on the market in all essential respects for the reasons discussed below.

II

Development planning is an example of what Adolph Lowe has described as "instrumental inference" [10, esp. pp. 325–344]. The principal characteristic of such an inference is that we are not interested in the task of "prediction" as such but in that of determining policies or controls that will ensure the attainment of certain specified goals or objectives. This is, of course, the same point that Tinbergen had made in his basic work on policy [14] when he pointed out that there was a logical inversion involved in passing from an "analytical model" to "policy models". Data and the unknowns change their places.

In the context of investment planning, which is the main area for which growth models are generally considered to be relevant, the main issue would centre around our ability to deduce the trajectories over time of output, consumption and investment levels that in some well-specified sense are optimal on the basis of initially specified capital stocks and such constraints as are considered inviolable. As regards "optimality", the problem is one of defining preferences over time which are in some sense congruent with society's ethical concerns. There are many basic logical issues over time such as what is the proper definition of 'society' from an intertemporal point of view. Is it ethically appropriate to express a preference for advancing the timing of future satisfaction? These and various other issues have been debated in the literature which we may assume as known in this context [2]. Suffice it to note that many people find it acceptable if the utility function over time were to be expressed as an integral of instantaneous utility levels of consumption per capita defined over the planning period. Debate on the question of what the length of the planning period should be is an intricate one, which, for our present discussion, will be assumed to be finite. Then we shall need to assume certain terminal conditions. As an alternative to the preference function mentioned above, we can also use the terminal value maximizing preference functions which many people do not find particularly appealing.

The question that I want to explore is whether growth models help us in *characterising* the class of paths that can be regarded as optimal in regard to the above-mentioned types of preference functions. To the question whether we can determine "generic" properties of optimal growth paths which arise from conjoint

operations of preferences and technology, the answer is in the affirmative. This I consider to be a major finding of optimal growth models. Their usefulness lies not in suggesting blueprints for immediate adoption but as possible benchmarks for purposes of carrying out dialogues between the planners and policy makers.

I shall only give two examples, one of which, a relatively simple one, has been widely discussed in the Indian literature while the other has been much discussed in the theoretical literature and is also beginning to find empirical applications.

I shall begin with the simpler case. This relates to the well-known two-sector model of Mahalanobis involving non-shiftable capital stock [11]. It is well known that this model was also discussed a great deal in the Soviet Union during the Twenties by Fel'dman [5]. While Mahalanobis was unaware of this work, and his derivation is formally much clearer than Fel'dman's, in both cases, there were certain key assumptions involved. These can be stated as follows: (i) there exist two vertically integrated sectors producing capital goods and consumer goods respectively; (ii) currently existing capital stock is sector-specific; (iii) current production of investment goods, which is a function of capacity in capital-goods sector, can be allocated freely (or subject to any *exogenous* constraint) between the two sectors; and, finally, (iv) there is no trade with the outside world. Given these assumptions and also the assumption that the production of consumption goods equals consumption. Mahalanobis demonstrated that a higher allocation of investment today to the capital-goods sector will entail a relatively favourable consumption level in the future. While he determined the allocation ratio exogenously, he clearly suggested that the capital-goods sector deserved higher priority in the initial stages of planning.

Was he justified in this conclusion? In the Sixties, several economists demonstrated that if the utility function was additively separable over time, the optimal solution not merely justified Mahalanobis's conclusion but a much stronger result. Put briefly, it was shown that the optimal solution in this model would show either investment specialization or consumption specialization in the initial phases except for a razor's-edge case which could in practice be ignored. For the case of a country like India, investment specialization appeared to be the relevant phase. See [2] and [4].

How robust was this conclusion? This was partly tested by Martin Weitzman [16]. This was done by relaxing the assumption of vertically integrated sectors. He dealt with the question of whether any qualitatively different conclusion would follow in a stylized three-sector model which allowed for the existence of a pure intermediate sector. His conclusion was that if there were no initial excess capacity in the system, then the three-sector model did not need to differ in any essential way from the two-sector model. The result would obviously extend if more than one pure intermediate sector was assumed.

This means that so long as the Mahalanobis assumptions were being maintained on the production side, possibilities of introducing shiftability indirectly through allocating a larger proportion of the output of the third (i.e. pure intermediate)

sector to one final demand sector or the other were unlikely to affect the qualitative character of the optimal paths.

We should pause here to consider whether our conclusion does not depend on a very unrealistic picture of the technological side of any economy. Clearly, the assumption of complete non-shiftability, while an exaggerated one, is not unrealistic in the absence of foreign trade. For the time being, however, we continue to maintain the assumption of a closed economy. It will then appear that our model, besides assuming shiftability, also makes the assumption of decomposability in the sense that there exists a sector which has a strategic significance in the process of real capital formation. This is the so-called "capital goods producing sector". Lowe considers this to be a sector whose importance for accelerating real capital formation cannot be over-emphasized [9]. Marx was the first economist to draw very special attention to the theoretical and practical importance of the existence of such a sector. As against Marx, the Austrian economists, notably Böhm-Bawerk, sought to reduce all capital to "wage advances", an idea which is intimately related to his specific proposal for measuring "capital" as a factor of production by means of an "average period of production". While it has been shown that Böhm-Bawerk's 'time measure' is logically untenable once a compound rate of interest is allowed for, Marx's scheme is free from such objection. Furthermore, empirical studies dealing with the correlation of availability of machine tools and the rate of capital formation are sufficiently strong to suggest that we are dealing here with a genuine constraint on the growth process [12].

It may be argued that while the availability of 'machine tools' may be an extremely important factor, their domestic *production* is not essential in the presence of "foreign trade". We should not forget that there may be significant advantages in importing these equipment goods in the early stage of industrial development. Clearly this is a very important point that needs some discussion. We can here distinguish between two polar situations. In situation A, there are no limitations on exports and imports at unlimited prices. Here there would be no restriction on introducing changes in the composition of capital stock, and instantaneous adaptation would be possible in the mix of national output. In such a situation, there are no structural problems of raising investment as a ratio of national income. And the earlier conclusion on the priority of producing equipment goods industry does not follow.

Let us now consider the other polar case. Here exports can be assumed as either strictly fixed or growing at an exogenously stipulated rate independent of investment allocation. In this case, however, it can be shown that we are not in a fundamental sense departing from the basic structural model. It has been shown that with the same preference function over time the strategic priority will shift in favour of *importing* self-reproducing capital goods, so that a domestic base can be created at a sufficiently fast rate.

Clearly, the assumption that exports are independent of investment allocations is a restrictive one. But it is not a bad first approximation for many *large size* countries. Further, even if we relax this assumption to allow for some variability in export possibilities directly resulting from varying investment allocations, one may conjecture that so long as we have not grossly misrepresented the "causal ordering" that prevails in the technological sphere, the critical significance of the 'equipment goods' industries is unlikely to change perceptibly if the time horizon is large and the preference function is of the additively separable type.

These last two characteristics bring us to a discussion of what is generally known as "turnpike theorems". The first such theorem was conjectured by Dorfman, Samuelson and Solow and provided the impetus for a very large body of work whose significance consists in the fact that irrespective of exact specification of the preference function, one could say something fairly precise regarding the structure of optimal paths so long as technology was represented by a pair of matrices known as the output matrix and the input matrix respectively and the preference function was defined as one of terminal value maximization. As a very important special case the Leontief dynamic model was included with or without the choice of technique. Subsequently, "consumption turnpike" theorems were added involving an integral of utilities of consumption per capita over finite time subject to initial and boundary conditions. Literature on this topic is vast and intricate. A very comprehensive account has been provided with numerical examples for the Leontief case with Japanese data by Tsukui and Murakami [15]. We can refer the interested reader to this book for details.

In contrast with our discussion of the two-sector model, we are here dealing with the case where capital goods can be unlimited in number, but, in keeping with the prototype model, we are still assuming away labour as an explicit constraint along with the possibility of foreign trade. Intuitively speaking, what the theorem states is that any optimal trajectory starting from given initial capacities where the optimum is defined with respect to a terminal value function will have three constructive phases ("the strong turnpike theorem"): (i) a first phase which consists in changing the initial composition of capital stock into one which sustains the maximum feasible rate of balanced growth nicknamed "the turnpike"; (ii) a second phase which consists of growth along the "turnpike"; and (iii) a third phase when it moves off the turnpike in directions which are indicated by the preference function.

It is shown that if T (the planning horizon) is sufficiently large, any optimal path stays outside of a properly selected neighbourhood of the turnpike no longer than a certain definite N of periods defined independently of T , so that the following must hold in the limit

$$\lim_{T \rightarrow \infty} \frac{T-N}{T} = 1 \quad \text{See [15; pp.4-45].}$$

If our technology is of the simple Leontief type, no matter how large, we can compute the "turnpike", i.e. the composition of capital stock which sustains the maximum rate of balanced growth from information regarding the two Leontief matrices on flow and capital coefficients.

The theorem is valid in this case only if certain special situations are ruled out which imply cyclic interdependence.² Tsukui and Murakami [15] have shown that our two cases involving foreign trade can be accommodated within the class of "turnpike theorems" by suitably extending the models. Using the Leontief framework, they have also computed numerical solutions for these cases as well as for the Japanese.

From our discussion so far, it is quite clear that growth models have non-trivial implications for development planning. In other words, in matters relating to the determination of volume and composition of capital stock along with choice of technique, we do get certain insights into the nature of optimal trajectories under certain well-specified restrictions on technology and preference. We find that the concept of "steady growth", which is descriptively unrealistic, can nonetheless provide us with significant normative propositions. We also note that a capital-using economy, no matter who manages it, will need to observe certain directional changes with regard to the composition of capital stocks, provided it has certain long-run interests in view.

Compared with the descriptive growth models, where the theory of the traverse in the sense of passage for one steady growth to another is still largely an un-explored territory, we are in a better position with regard to the treatment of planning questions. The question that may be raised at this stage is whether we have not in some critical respects oversimplified the planning problem so as to provide us with tractable situations. We turn to a discussion of these issues in the next section.

III

The first point to note about our earlier discussion is that we have reduced the problem of development planning to the planning of real capital formation. Clearly, there is very much more to the problem of development planning than planning real capital formation. There are many profound and complex problems involving adaptations of institutional structure of a developing society which deserve very careful attention. Clearly, growth models cannot help us in determining these changes. However, in so far as rapid capital accumulation can be shown to be a desideratum of economic policy, growth models can provide us with some significant criteria for evaluating recommendations for such changes. This is because the types of models we have considered make use of institutional categories such as profits and wages in a relatively inessential manner.

²To rule out these cases, empirical information is called for.

Even without committing oneself to a 'convergence theory' it is possible to maintain that there are certain kinds of *vertical* and *horizontal* relations of compatibility which a growing economy must necessarily obey. A better understanding of these relationships is one of the principal contributions that growth theory has made to our pool of economic knowledge. When one looks back on the past literature on business cycles, one can see better why discussion had to be so very ad hoc as they mostly regarded a stationary equilibrium as the benchmark for most of their discussion. Similarly, classical theories of comparative advantage suffered from the failure to take into account the implications of sustained rates of change. Our evaluation of commercial policies may have been accordingly biased in the direction of what people have described as 'existing' rather than 'incremental' comparative advantage.

To get people to think systematically in terms of rates of change rather than in terms of absolute levels is undoubtedly an improvement whose value few will deny. But some may wonder whether we have not been guilty of drawing practical policy conclusions from relatively simple constructs.

I believe that there is some substance in this charge. But we should be careful about the exact nature of this charge. It is not possible to maintain that a more elaborate model is necessarily superior to a simpler one. Much depends on the realism and relevance of a strategic simplification that a model may embody. Thus, I feel that the main limitation of the Mahalanobis model in regard to India does not lie in its neglect of foreign trade or of intermediate sectors for the reasons stated earlier, but in its treatment of 'real wages' implicit in the model.

While it may not be more realistic to make the assumption of adaptive real wage rate for a fully planned economy, the question is altogether different for a mixed economy. Furthermore, in an economy where food constitutes a primary constituent of the real wage basket, and agriculture depends largely on land, to postulate a fixed capital-output ratio is an unduly optimistic assumption based on ignoring diminishing returns for ever.

Similarly, when we move to the discussion of 'turnpike theorems' for the general von Neumann model, we postulate invariant technological possibilities along with a fairly rigid formulation of an intertemporal preference function. While the question of expressing our preferences for future consumption in a fairly flexible manner is yet a relatively unexplored area, some relaxations are being made in regard to the assumption of fixity of technology matrices. But then the model loses its appealing simplicity.

I now turn to a very live contemporary issue in planning. This relates to the discussion on employment generation in less developed countries. If we can assume that real wages are fixed until full employment is reached, and technology is given once and for all, then we can show that the maximum rate of balanced growth, i.e. the turnpike, constitutes a time-minimizing solution to full employment. This may imply that along the way we can have a *significant* amount of unemployment

initially even though the unemployed are being drawn into productive work as fast as possible. A pertinent question, however, is what do we do about the unemployed today. This implies that we have to find out methods by means of which we can take care of the entire population, not merely of those who are going to be employed.

Clearly, we cannot give any answer to this highly complex question of treating the problem of present-future choice or the distribution of incomes amongst the contemporaries as two mutually disjunct sets of issues. Formally, both aspects may be combined by adding weightage to the fate of the currently unemployed in specifying our preference function over time. Given the information provided by technology, we can then work out the implied optimizing solutions.

But three difficulties appear as important. Firstly, we have to devise a method of effecting transfers to those who are not employed today; secondly, we should seek to avoid the choice of technology which implies an avoidable loss on current output; and, finally, we should ensure that the quantum and structure of capital formation change in an appropriate long-run sense.

Of these three problems, the first refers to a whole complex of issues relating to ensuring effective social security arrangements. The second issue pertains to the much-debated questions of an "appropriate technology". The third refers to the classical problems of capital accumulation.

How much light do the growth models shed on answering these basic questions? Typically, growth models are supposed only to help as aids to clear thinking on the third set of questions. This is because these models do not pay attention to the composition of consumption demand by household groups. If the distribution of income is solely dependent on the market mechanism and all labour were assumed to be homogeneous and uniformly available at a given wage rate, then obviously we have to think of the so-called *non-economic* methods of arranging for consumption of those who are unemployed. But if we think in terms of a modified market mechanism, i.e. we visualize a system of appropriate taxes and subsidies, the level of employment can be shown to increase consistent with a certain desired rate of growth of capital accumulation so long as the desired rate is less than the maximum technologically permitted one.

This is obviously an important gain. But the question remains as to how best to implement such a comprehensive system of taxes and subsidies. Here the problem arises whether we cannot organize labour directly in teams which will create capital on the margin through redistributing current consumption. In this situation, certain vertical relationships in production between directly productive capital and social overhead capital may be effected through introducing non-market models of mediation but the maintenance of horizontal relationships may be left to the modified market mechanism. In organizing these non-market models of inter-mediation, the question of property rights comes up along with the problem of intermeshing decisions on different levels of planning. The issue is best seen in the context of organizing public

works. While the issue merits a lengthy decision, I shall not venture any discussion here. Suffice it to note for the present that the existence of problems of this nature does suggest that development planning must increasingly get to grips with problems of information, ownership and control, issues which have been very lightly touched upon in the existing literature. It also means that our use of certain simple growth models needs to be greatly qualified by a greater awareness of certain real life issues they abstract from. However, all this does not suggest that we need to throw away the "growth models" as irrelevant exercises and start all over again. I think that, properly interpreted, they have important lessons for us which no capital-using form of society which is also a growing one can afford to ignore.

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