A PLANNING MODEL
FOR THE EDUCATIONAL REQUIREMENTS OF ECONOMIC DEVELOPMENT
THE CASE OF IRAN

G.H. Baher

INTRODUCTION

> "One would naturally like the growth model to be as realistic as possible. Unfortunately, greater economic realism can only be achieved through greater mathematical complexity. A compromise must therefore be accepted. The problem is to find one which is appropriate for our purpose , since we want the growth model to be mathematically simple, we cannot expect it to be very realistic. We can only demand that it enables us to draw certain generally valid conclusions which are essential to our purpose."
>
> M. Inagaki*

Referring to the choice of the growth model, Professor Inagaki in his brilliant work[1] points out a celebrated view which is, more or less, a common feature of all economic activities. Obviously, in order to achieve practical usability, any mathematical model used in economics requires some simplifications for assuming the reality to be a little simpler than it in fact is. What is a worry, therefore, is not the existence of simplifying assumption as such, but those specific ones that seem to put us on the wrong track altogether.

---

*Professor of Economics and the Director of International Institute for Quantitative Economics.

[1] Optimal Economic Growth, p.3, [10].

Following Professor A. K. Sen [18], it seems permissible to say that the relation between theory and statistics is an intricate one. Theories, to be empirically sound, must be based on data, but statistics, in their turn cannot be efficiently collected and compiled without some notion of a background theory.

In a new field like that of the economics of education and that of manpower planning, such background theories can prove to be the biggest stumbling blocks. A number of approaches have cropped up in the field, and statistical works seem to be proceeding in a variety of directions.

It is not altogether clear, however, whether all these approaches are practically promising. Since the quality and the amount of data leave a lot to be desired, rejection or verification is not very easy. It is, therefore, all the more necessary that the underlying logic of the background theories be very carefully examined, to make sure what exact economic assumptions they imply, and to what extent these are plausible relations to expect.

The main objective of this paper is to present and examine the Tinbergen, Correa and Bos approaches to the problem of education and manpower planning, which have been widely argued in the last decade, and to apply a simple type of that model to the Iranian educational system.

Therefore, the paper consists of two parts followed by a mathematical appendix and a list of references. Part I, which is of a more theoretical nature, deals with Professors Tinbergen, Correa and Bos' approaches to the educational planning. The improvement of the models as well as some sound comments made on them will be argued accordingly. Part II works out the applications of a simplified version of the Tinbergen/Bos model to the educational system of Iran. In doing so, by using the real data of the year 1966 in the adjusted model, the balanced growth of the Iranian educational system has been claculated for three time periods.

In the light of this assessment, I feel deeply indebted to the works done by all the authors listed in the references. The work done by Dr. F. Aminzadeh at Iranian Plan Organization was of great assistance in this approach.

PART ONE

PRESENTATION OF THE MODEL

Aim:

The aim of the model is to represent the link between economic development and that of the educational system of a nation and, therefore, to describe the demand flows for various types of qualified manpower to be expected from the organizers of production and of education.

Characteristic Assumptions:

In building the model, certain basic facts are taken into account such as [20] :

"1. economic life needs a stock of qualified manpower; the flow of new graduates from educational establishments represents a very small proportion of this stock in view of human longevity;

2. education often consists of a series of successive stages, each depending on the former for its supply of new recruits, e. g. expansion at university - level would be impossible if sufficient secondary -level graduates were not available;

3. parts of the stocks of qualified manpower must be used in the education process itself as needs are used in agriculture;

4. qualified manpower may be imported".

The Basic Model:

In the light of starting point for the sake of brevity let us consider the simplified version of the model first published in " KYKLOS" [6];

$$1.\quad N_t^2 = \nu^2 V_t$$

$$2.\quad N_t^2 = (1-\lambda^2)N_{t-1}^2 + m_t^2$$

$$3.\quad m_t^2 = n_{t-1}^2 - n_t^3$$

$$4.\quad m_t^3 = n_{t-1}^3$$

$$5.\quad N_t^3 = (1-\lambda^3)\, N_{t-1}^3 + m_t^3$$

$$6.\quad N_t^3 = \nu^3 V_t + \pi^2 n_t^2 + \pi^3 n_t^3$$

Where:

V = total volume of production (income) of the country

N^2 = the labour force with a secondary education

N^3 = the labour force with a third-level education

m^2 = those who have entered the labour force N^2 within the previous 6 years

m^3 = those who have entered the labour force

N^3 within the previous 6 years

n^2 = the number of students in secondary education

n^3 = the number of students in third-level education

ν^2 & ν^3 = fixed coefficients wich determine the relationships between production and the labour force with a secondary education and third-level education respectively

λ^2 & λ^3 = fixed coefficients which determine those already in the labour force with a secondary education and third-level education respectively, one period earlier and have dropped out owing to death or retirement.

The Interpretation of Equations:

In the model, equations (1) and (6) will simply stand for the requirement equations of the two capital goods N^2 and N^3, the capital coefficients being assumed fixed. Equations (2) and (5) express the fixed proportion depreciation of the two kinds of capital goods and the rate of their growth given by new additions to the stock. Equation (3) represents that capital goods of type N2 can also be used as an intermediate product for the production of N^3, which is a more refined product, and equation (4) will express only the fact that capital goods produced in this peroid are available for use in the next.

Main Features of The Model:

1. The above-mentioned model which is an approach in

the context of the quantitative adaptation of education to accelerated growth, consists essentially in postulating fixed relations between stocks of educated manpower and units of national income. It implicitly assumes away the possibility of substitution between educational resources and productive factors of other kinds.

2. In this model, labour units both secondary and third-level education appears as capital goods with rigid relationships to real national income. These relationships are linear, i.e. fixed " capital-output ratios" are assumed to prevail for human capital. Equation (1) and the first component in equation (6) together form a Leontief-type[1] set of production functions.

3. There are two scarce resources viz.," the total stock of people with a secondary education (N^2) ," and "those with a third-level education (N^3) " for time period T.

4. As already mentioned, the need for N^2 is taken to be simply proportional to national income and the same for that part of N^3 which is used for producing national income; but there are two other parts of N^3 employed in teaching people at the secondary and the third-level, these requirements are also taken to be proportional.[2]

5. The stocks of secondary and third-level educated manpower of this period depends on the stock last period minus the part of the last period's stock eliminated by death and retirement. This "drop-out" is taken to be a fixed proportion of the last period's stock.

6. Because of the distinction between two types of human capital: educated manpower (i) necessary to attain a certain level of real income and (ii) teachers needed to produce educated manpower, the model gives more insight in to the structure of a growing economy than traditional growth model based on real capital and assuming that capital is a homogeneous factor.

---

1. Linear-Limitational, i.e. any possibility of substitution between secondary third-level educated labour is excluded.

2. The assumption of "given teacher-pupil ratios."

to the structure of a growing economy than traditional growth model based on real capital and assuming that capital is a homogeneous factor.

7. Since it has been assumed that the primary educated people are abundant, therefore, manpower of this type is not considered to be a scarce factor of production in the model.

These are the main features of the first model by Tinbergen/Correa and the rest consists in the working out of the implications of all these and of a few other minor assumptions.

The Mechanism Of The Model:

The model wich is called "the balanced growth model" has been built on the rationale that "the ideal development of the educational system is one of regular growth parallel to the desired growth of the economy. " [1] Therefore, if the economic variables develop with a constant rate of growth, it is possible to find one path of development of the educational variables showing the same rate of growth.

According to the model, each growth rate of the economy is linked to a certain structure of the educational system. As soon as the parameters of the equations of the model are estimated, the equilibrium structures for alternative rates of growth of the real product may easily be derived. therefore, once an equilibrium structure has been attained, the process of balancedgrowth starts, and it continues as long as the rate of growth of real income remains constant.[2]

---

1. A planning Model for Educational Requirements of *Economic* Development, p. 150 [20].

2. Taking for granted that the structural parameters do not change.

Mathematical Interpretation of the Balanced Growth Model:

The process of the balanced growth looks very simple. Because of the assumption of linearity, all variables grow at a constant rate. If we write down the relationships between the rate of growth of real product and the variables with wich educational policy is concerned as elasticity coefficients, all elasticities would amount to unity. As long as we are concerned only with such states of balanced growth, we may forget the time suffixes; the system then appears to be "timeless;" this is typical for any equilibrium solution of dynamic models. A simple final equation would establish the relationship between income growth and the development paths of the variables of the educational system.

Necessity of Long-Term Perspective Educational Planning:

Economic development, in the ways it is proceeding nowadays, is essentially a matter of the creation and assimilation of technological progress. This affirmation should be complemented by another one: technological progress is principally a matter of the quality of the available human factors. Abundant studies now available demonstrate that the development of an economy is partly a function of the sum total of the human factors. Here we are faced with the most complex of all the problems involving the formulation of a development policy, that improving the human factors takes time, and it is possible only if adequate forming patterns are available. Therefore, we lead to the significance of the educational long-term planning along with the development planning of a given economy.

The main aspects of any educational long - term plan should be:

a. Embracing a serious politico-sociological study of the problem of how, and how far, traditional educational patterns had contributed to the failure of social and economic progress in the past. Such a study is the essential basis of all educational planning. It must discover whether the attitudes which are hostile to economic progress have been the result of a specific structure of education,and what Modification of that structure are needed to obtain in a new apprach to the technical requirements, in terms of knowledge and training of economic expansion.

b. The other main aspect of any long-term educational planning demands an idea of the shape of economic development that is hoped for.

Ability of the Model for Perspective Planning:

At this stage of study, we are interesed in knowing if the Tinbergen/Correa model (hereafter Tinbergen-I) has the ab lity of long-term planning or not.

We have already mentioned that in an equilibrium solution of such a dynamic model, a simple final equation would establish the relationship between income growth and the development paths of the variables of the educational system. Such a final equation shows the boundaries of the model for the purpose of longrun educational planning.Following Bombach [4] we may assume a growth rate of real product 5 percent year. According to the Tinbergen-I model, third-level manpower would have to increase by the same rate.It may furthermore be assumed that total labour force increases by 1percent annum, and that at the beginning of the period of balanced growth. the share of the third-level in total manpower was 5 percent it would take only 75 years (or about 12 unit periods assuming each period of time equals to 6 years) in order to make total labour force 100% unicersity trained, which is rather a silly result.

Transition Problems:

In combating with unfair results of the model and in order to make the approach more realistic , i.e. considering accelerated economic development , the transition problems have been introduced.[1] Of course, by introducing the transition process and productivity increase accordingly, the results of the model do not look so off base as before. But we are left with the same fundamental difficulty as long as one sticks to constant (hoewer different from unity) elasticities, but with differences in grade. With the elasticity coefficient above unity, the shares of secondary and third-level educated manpower always move against the 100 percent margin; only it takes less time. An elasticity smaller than unity, on the other hand, causes the shares to develop towards zero, which is also impossible.

Hence, it is permissible to conclude that for long-term considerations over-simplified relationships between growth rates and educated manpower requirements are bound to be misleading.

Problems Caused by Over-Simplification:

We are already aware of the misleading consequences caused by some over-simplification assumptions. Taking into account such difficulties, Tinbergen and Bos have tried to revise the basic model (Tinbergen-I) through some possible generalization. The refinements they have made to counteract some of the drawbacks of over-simplification are as follows:[2]

" a. giving a more general form to the demand function for manpower of various types;

b. disaggregating production into a number of sectors having different manpower requirements;

---

1. Transition problems have been explained with the presence of foreign aid and without it. For more details refer to [20] pp. 151-155 .

2. *A Planning Model* [20] , p.159 .

c. creating a method of dealing with drop-out in education;

d. providing an alternative method of treating retirement;

e. introducing more stages in the educational process;

f. introducing smaller time units into the time structure;

g. eliminating surpluses of certain types of manpower."

The Revised Model:

By elaborating some aspects of the basic model, Tinbergen and Bos have introduced a revised model (here-after Tinbergen-II); its main aspects are follows:

1. Instead of simple proportionality (linear relation) and constant coefficient (ν^2) between manpower stock with secondary, third-level education (N^2 , N^3) and the level of production (V_t), the following relationships have been assumed:

$$(1a) \quad N_t^2 = \nu^{20} V_t^{\nu^{21}} \left(\frac{V_t}{a_t} \right)^{\nu^{22}}$$

$$(6a) \quad N_t^3 = \nu^{3o} V_t^{\,31} \left(\frac{V_t}{a_t} \right)^{\nu^{32}} + \pi^2 n_t^2 + \pi_t^3 \, n_t^3$$

In equation (1a) the stock of manpower with secondary education is a function of the level of production (V) and the per capita income ($\frac{V}{a}$) .[1] In this relationship, per capita income measures approximately the inverse effect of in-

1. _a_ represents the number of total production.

creasing labour productivity on the demand for manpower. [1]

Similarly, this effect is measured on the demand for manpower stock of third-level education in equation(6a).[2]

2. The next elaboration of the model is disaggregating production (or total national income) into a number of sectors with different manpower requirements. For the sake of simplification, in the Tinbergen-II model, only two

---

1. In order to simplify equation (1a), Tinbergen and Bos have supposed the time paths of V_t and a_t were as follows:

$V_t = V_o{}^{\omega t}$ or, approximately, $V_t = V_{oe}{}^{\omega' t}$, if $\omega' = \omega - 1$ and

$a_t = a_o{}^{\alpha t}$ or, approximately, at $= a_{oe}{}^{\alpha' t}$, if $\alpha' = \alpha - 1$

By substituting these equations in (1a), they have found:

$N_t^2 = W_o^2 e^{\psi' t}$ or, approximately, $N_t^2 = W_o^2 \psi_2^t$, if $\psi'_2 = \psi_2 - 1$

where $W_o^2 = \nu^{20} V_o{}^{21} + \nu^{22} \quad a_o^{-\nu^{22}}$ and $\psi_2 = (\nu^{21} + \nu^{22})\omega' - \nu^{22}\alpha' + 1$

2. By using the above assumptions about the time paths of V_t and a_t it is possible to replace the first term on the right-hand side of equation (6a) by the expression:

$$W_o^3 \; \psi_3^t$$

Where $W_o^3 = \nu^{30} V_o^{\nu^{31} + \nu^{32}} \; a_o - \nu^{22}$

and $\psi_3 = (\nu^{31} + \nu^{32})\omega' - \nu^{32}\alpha' + 1$

It should be mentioned that the ν coefficients will not be the same for second and third-level manpower. The coefficients W_o^2 and $\psi 2$, therefore, will be different from W_o^3 and $\psi 3$ respectively.

sectors have been considered to comprise the whole economy. Therefore, equations which are based on production, i.e. equations(1) and (6) are reformulated for any of the sectors separtely and two other definition equations have been added to the model.

The new equations are:

(3.1a) $1N_t^2 = 1\ \nu^2 V_t^1$ (3.6a) $1\ N_t^3 = 1\ \nu^3 V_t^1$

(3.1b) $2N_t^2 = 2\ \nu^2 V_t^2$ (3.6b) $2N_t^3 = 2\nu^3 V_t^2 + \pi^2 n_t^2 + \pi^3 n_t^3$

(3.1c) $N_t^2 = 1N_t^2 + 2N_t^2$ (3.6c) $N_t^3 = 1N_t^3 + 2N_t^3$

Where:

V^1 = net output of sector 1

V^2 = net output of sector 2

$1N^2$ = labour force with a secondary education in sector 1

$2N^2$ = labour force with a secondary education in sector 2

$1N^3$ = labour force with a third-level education in sector 1

$2N^3$ = labour force with a third-level education in sector 2

It should be mentioned that in equation (3.6b), the teachers of both level of education have been included in sector 2.

3. In equation (3) in the Tinbergen-I model, the number of newcomers to the labour force with a secondary equation was equal to the number of students one time unit earlier minus the number of students now in third-level education. Therefore it was implicity assumed that all students enrolled at secondary schools will, one period later, either join the labour force with secondary education or be enroll-

ed in the third-level education.

It is clear that such an assumption is far from reality because (a) not all students enrolled in a given level of education will necessarily graduate after six years[1], and (b) there is no certainty that all graduates will either join the labour force or will continue their education towards a higher level.

Hence, in modifying the model, equations (3) and (4) have been reformulated as follows:

$$(4.3) \quad m_t^2 = \mu^{21} n_{t-1}^2 + \mu^{22} n_{t-1}^3 - n_t^3$$

$$(4.4) \quad m_t^3 = \mu^3 n_{t-1}^3$$

here:

μ^{21} = fraction of the number of students enrolled at secondary schools one time-period earlier;[2]

μ^{22} = fraction of the third-level students who do not complete their studies and join the labour force with a secondary education;[3]

---

1. Some do not complete their studies; others fail their examination and may complete their education in longer periods than what is assumed equal 6 years.

2. This fraction has been assumed to be numerically proportional to the number of third-level students one period earlier.

3 and 4 this fraction has been assumed to be numerically proportional to the number of third-level students one period earlier.

μ^3 = fraction of third-level students who finish their studies within a given period and join the labour force with third-level education.[4]

4. Considering equations (2) and (5) of the basic model (Tinbergen-I), we find out that the drop-outs owing to death - or retirement are assumed as a proportion (λ^2 and λ^3)of those already (one unit of time earlier) in labour force. Since the amount of this proportion depends on the age composition of the stock of manpower, the assumption made in equations (2) and (5) of the basic model is too simple and misleading because in the case of rapid development, the age composition of the stock of qualified manpower is biased in favour of younger generations. Therefore, in order to be more precise, a distinction between the various age classes of the manpower stock is required. Furthermore, the application of retirement rates characteristic of each age class is also needed.

Since such precise treatment introduces far more time units than are in the basic model which make it considerably complicated, Tinbergen and Bos have made a simpler approach to adapt the numerical values of the coefficients λ^2 and $\lambda^3$to the prevailing conditions. By introducing factor T standing for the productive life of an individual, they have replaced equation (2) by:

$$N_t^2 = N_{t-1}^2 - m_{t-T}^2 + m_t^2$$

in which m_{t-T}^2 represents the number of those who entered the secondary educated labour force T time units earlier. In this equation, it is assumed that retirement takes place only due to old age.

Comparing equations (2) of the basic model with this reformulated one, it can be shown that $\lambda^2 = \frac{\omega-1}{\omega^{T-1}}$ where ω is the ratio of production in year T to that in year t-1.

5. Another possible generalization to be made in the model is considering the education processes more than two (secondary and third-level). Sometimes it seems useful to split up

third -level education into different fields. Supposing three major fields: arts, science and engineering as the breakdown of the third-level education, it is possible to replace equation (3) of the basic model with the following:

$$m_t^2 = n_{t-1}^2 - n_t^a - n_t^s - n_t^e$$

Where n_t^a, n_t^s and n_t^e stand for the number of students in the art, science and engineering departments respectively.

6. Considering a uniform education period of six years for both secondary and third-level education and consequently appearing only one lag in equations (3) and (4) due to that assumption, considerably simplifies the calculations to be made and is misleading as well. If the education periods are different for secondary and higher education , one has to use a shorter unit period for the model, and the various education periods have then to be expressed in multiples of the unit period. This would result in more complicated (higher order) systems of difference equations.

Tinbergen and Bos are of the opinion such refinement in time structure " may be required, and would be desirable (though not absolutely necessary) if the duration of the two stages of education differs."

7. The last elaboration which has been made in the basic model is about the elimination of surpluses of a given educational attainment from the labour force. The available labour force with a given level of education may surpass the needs of the economy for that particular type of manpower. This may be expressed by unemployment, inefficient use of labour and /or relatively low salaries,and may affect all graduates of a given level, (e.g. university)or only those in specific fields (law, humanities).

Tinbergen and Bos have explained a way for Planning the elimination of such a surplus in one time unit and two time units.

Summary of the Modifications Made in the Basic Model

Tinbergen and Bos, as already mentioned, developed the basic model by introducing some changes, without altering the basic approach. These changes are as follows:

1. Considering a fixed proportion of "wastage" (e. g. due to failure to pass or to continue study, due to seeking education for purely cultural reasons without wanting - to use it).

2. The possibility of an initial surplus of some kind of educated stock.

3. Relating manpower requirements to sectoral components of national income, and not to aggregated national income altogether.

4. Taking a not-necessarily proportional, but unique relation between educated manpower and the product.[1]

We may note for example, postulate that when output goes up 10 percent the stock of secondary educated manpower requirements goes up by 5 percent. But while this relation is not proportional, it is unique, in the sense that a 10 percent increase in output requires a fixed amount of expansion of the educated stock, no matter what else we do in the economy. We cannot cut down the requirement of educated stock by choosing other techniques of production requiring, say, less of this kind of education.

PART TWO

THE CASE OF IRAN

Investigations and prognostications, undertaken during the last few years, concerning population explosion in Iran have guided the planners in Iran to include a population variable in the development plans of the country. Hereunder, in order to have some idea about the population problems, there is a brief account of the composition of population and its educational characteristics in Iran in 1971.[1]

Population

Iran's population has been increasing rapidly in recent years from 25.8 million in 1966 (second census in Iran) to 30.2 million in 1971. Thus, within the past five years, Iran's population has increased by 17 per cent; and 55 per cent from the first census[2] (1965).

The relative population density in 1971 was more than 18 persons per square kilometer. About 41 per cent of the population resided in the urban areas[3] and the rest in the rural areas. Another characteristic of Iran's population in recent years has been its skewness in favour younger groups. In the census of 1966, around 55 per cent of the population was in the 20-year-old or less age group; this per-

---

1. The latest available formal data (Central Bank Of Iran , Economic Report 1971).
2. Figures for Iran's population in 1971 have been taken from the estimates of Iran Statistical Center.

3. All centers of provinces and localities with population of more than 5, 000 (Iran Statistical Center).

centage was 57 in 1971. The youth dominated population pyramid has necessitated new investments in education, training, health and social welfare and has posed serious questions concerning employment which makes it imperative to include or employment variable in the next plans.

Education

In 1971, considerable increase in the number of students as well as schools was quite noticeable. The number of elementary schools reached 15, 000 with 3 million students and educational corps[1] schools with a 30 per cent increase registered 11, 000 with a total of 504,000 students . Notwithstanding the fact that there are now 3.5 million students in elementary schools (11.6 per cent of total population) and that efforts of educational corps in the fight against illiteracy have not been successful enough, as there is still a large portion of 6-12 year old group which is not receiving compulsory[2] elementary education. According to the latest estimates, about 55 percent of of educationally eligible children in 1971 have had access to the country's schools. The same ratio for 13-18 year -old age group (secondary school students) reaches 18 per cent. Nonetheless the number of secondary-school students registered in 1971 a cose by 13 per cent and accounted for more than one million. In 1971, following the trend of recent years, the number of students enrolled in technical and professional schools was not sufficient to meet the ever-increasing needs of new industries in the context of economic expansion. Considering the need for rapid rate of growth of industries, the shortage of technical trainees, who only consisted of 3 per cent of total student population, was quite noticeable against the sharp needs of the country for manpower with average technical abilities.

---

1. Literacy corps is one of the twelve-point of so- called "White Revolution" initiated since 1962.

2. Iran tatistical enter.

The number of university and higher education students reached 75, 000 of which only 25 per cent were girls. The increase in the number of university students in recent years has been quite substantial, increasing by one and half fold from 1968 to 1971.

Application of the Tinbergen/Bos Model to the Educational system of Iran

In order to explain the procedures followed to apply the Tinbergen/Bos model to the Iranian educational system, first the general modified model will be exposed, and then along with the explanation of the equations and the measurements of the coefficients, the rationale of the steps which have been followed will be tackled.

Finally, by using the estimated coefficients, we will calculate the pattern of balanced growth for 3 time periods accordingly.

(1) $N_t^2 = \nu^2 v_t$

Modified Model

(2) $N_t^2 = N_{t-1}^2 - m_{t-T^2}^2 + m_t^2$

(3) $m_t^2 = \mu^{21} n_{t-1}^2 + \mu^{22} n_{t-1}^3 - n_t^3$

(4) $m_t^3 = \mu^3 n_{t-1}^3$

(5) $N_t^3 = N_{t-1}^3 - m_{t-3}^3 + m_t^3$

(6) $N_t^3 = \nu^3 v_t + \pi^2 n_t^2 + \pi^3 n_t^3$

Equation(1)

Equation (1) links requirements of secondary educated manpower to the volume of production. This relationship has been assumed to be numerically proportional. The parameter which relates secondary educated manpower(N_2) to the volume of gross domestic product (V_t) and has been shown by ν^2 can be interpreted as the inverse of ordinary labour productivity ratio ("labour coefficient" in input-output terminology), with the modification that it refers to educated manpower only.[1]

The value of ν^2 for the Iranian economy has been accounted for the year 1966:

$$\nu^2 = \frac{N^2_{66}}{V_{66}} = \frac{174.3}{6840} = 0.025 \quad ^2$$

The time unit (t) has been assumed of six years. The education period for secondary level is 6 years in Iran, and for the sake of simplification, it has been assumed that the average period for third-level education is also equal to 6 years.

---

1. Equation (1) in this sense has been treated as a production function. Following Professor Bombach [4],it is possible to interpret that equation in quite a different way, namely as consumption rather than a production function. When people become richer they want to be better educated,regardless of whether they really need this education for their job or for getting higher education for the sake of self-satisfaction. Considering Iranian students, especially the pupils studying in high-schools, there is a high proportion of female students who receive education without any desire to enter a professional career . This seems a strong reason to be much in favour of consumption function approach rather than production.

2. In this calcluation, the unit for N^2 and V one thousand students and one million dollars respectively.

Equations (2) and (5)

These equations are identity-type equations which equate respectively the stocks of secondary and third-level educated manpower this period with the stocks of these people one time unit earlier, plus those who have joined them during the previous 6 years minus those already in the labour force one period earlier have dropped out owing to death or retirement. In these equations, T^2 and T^3 stand for the productive life of individuals with a secondary and a third-level education respectively.

According to the measurements made for the productive life of manpower in Iran[1], these life-time manpowers with a secondary and a third-level of education have been estimated 48 and 42 years respectively. Considering the unit of time equals 6 years, the values of T^2 and T^3 are:[2]

$$T^2 = 8 \qquad\qquad T^3 = 7$$

Equations (3) and (4)

According to equation (3), the number of persons joining the labour force with secondary education will be equal to a fraction (μ^{21}) of the number of students enrolled at secondary schools one time-period earlier, plus those third-level students who do not complete their studies[3] with a

---

1. Social and Economic Bureau, plan Organization, Iran .
2. By using $\lambda = \frac{\omega - 1}{\omega^{T} - 1}$ where λ stands for the fraction already dropped out one time unit earlier and ω as the ratio of production in the end of period t to that in the end of period T-1, we find: $\lambda^2 = 0.011$ and $\lambda^3 = 0.018$.
3. Assumed to be numerically proportional to the number of third-level students one period earlier.

coefficient (μ^{22}) minus those who have completed their secondary education and continue their studies at the third-level.

Equation(4) expresses that the number of persons joining the labour force with a third-level of education is a fraction (μ^3) of the number of students enrolled at the third-level one period earlier.

It is worthwhile to be mentioned that $\mu^{22} < 1-\mu^3$; since $1-\mu^3$ includes both the proportion of third-level students who do not enter the labour force at all and of those who do not complete their studies, while μ^{22} includes only the latter proportion.

The values of μ^{21}, μ^{22} and μ^3 in the case of Iran have been calculated as follows [1] :

$$\mu^{21} = 0.38$$

$$\mu^{22} = 0.011$$

$$\mu^{3} = 0.87$$

Equation (6)

Equation (6) is also an indentity equation which equates the manpower with a third-level education to the sum total of those employed in production[2] and of those teaching at both levels of education.[3] In this equation, ν^3 is the ratio of third-level graduates to the volume of production (Gross National product in the case of Iran)and its value has been accounted in year 1971 as

---

1. Refer to appendix.
2. The number of third-level graduates employed in production is assumed to be proportional to the volume of production.
3. The numbers of those teaching at secondary and third-level studies are assumed to be proportional to the respective student numbers.

$$\nu^3 = \frac{53.2}{6840} = 0.008$$

π^2 and π^3 stand for teacher-student ratios at secondary and third-level of education respectively. Their accounted values for Iran are:

$$\pi^2 = 0.03$$

$$\pi^3 = 0.07$$

these last two coefficients , imply 35 and 15 students per teacher respectively.

The model with estimated coefficients, therefore, is:

$$(1.a)\quad N_t^2 = 0.025V_t$$

$$(2.a)\quad N_t^2 = N_{t-1}^2 - m_{t-8}^2 + m_t^2$$

$$(3.a)\quad m_t^2 = 0.38n_{t-1}^2 + 0.011n_{t-1}^3 - n_t^3$$

$$(4.a)\quad m_t^3 = 0.87n_{t-1}^3$$

$$(5.a)\quad N_t^3 = N_{t-1}^3 - m_{t-7}^3 + m_t^3$$

$$(6.a)\quad N_t^3 = 0.008V_t + 0.03n_t^2 + 0.07n_t^3$$

For the sake of simplification, it seems permissible , instead of using equations (2.a) and (5.a) to apply the following equations:

$$(2.b)\quad N_t^2 = (1-\lambda^2)\, N_{t-1}^2 + m_t^2$$

$$(5.b)\quad N_t^3 = (1-\lambda^3)\, N_{t-1}^3 + m_t^3$$

in which the values of λ^2 and λ^3, as already calculated,[1] are:

$$\lambda^2 = 0.011 \quad \text{and} \quad \lambda^3 = 0.018$$

1. See p.25 of this paper.

Therefore the model is:

(1.b) $N_t^2 = 0.025V_t$

(2.b) $N_t^2 = 0.989N_{t-1}^2 + m_t^2$

(3.b) $m_t^2 = 0.38n_{t-1}^2 + 0.011n_{t-1}^3 - n_t^3$

(4.b) $m_t^3 = 0.87n_{t-1}^3$

(5.b) $N_t^3 = 0.982N_{t-1}^3 + m_t^3$

(6.b) $N_t^3 = 0.008V_t + 0.03n_t^2 + 0.07n_t^3$

Pattern of Balanced Growth

Assuming that economic variables develop with - constant rate of growth, it is possible to find a path of development of educational variables showing the same rate of growth. This pattern of development, as already mentioned, is called " Balanced Growth." For a system to move along such lines, the initial circumstance (to be indicated a suffix t = o) have to satisfy certain conditions.

In order to establish the above-mentioned conditions for the case of Iran, assuming the exponential pattern of growth, i.e. $V_t = V_o\omega^t$ in which V_o is the initial value of V, and ω is the rate of growth per six-year period, we take the following steps:

Considering the formal growth rate of economic development per year, say 9 percent,[1] the rate of growth per six-year period should be:

$\omega = (1+0.09)^6 = 1.68$

---

1. This rate has been established for gross national products of Iran by the Fourth Development Plan.

Therefore, the time path of the economic growth should be:

$$V_t = V_o\, 1.68^t$$

This path of growth is characterized by an increase in gross national product of 68 per cent per six-year period. Hence, the assumptions of the balanced growth are:

$$N_t^2 = N_o^2\, 1.68^t \qquad N_t^3 = N_o^3\, 1.68^t$$

$$n_t^2 = n_o^2\, 1.68^t \qquad n_t^3 = n_o^3\, 1.68^t$$

$$m_t^2 = m_o^3\, 1.68^t \qquad m_t^3 = m_o^3\, 1.68^t$$

By substituting these assumptions in equations (1.b) to (6.b) of the model, we shall find the following conditions fulfilled by the initial values:[1]

$$\underline{N_o^2} = 0.025V_o \qquad \underline{N_o^3} = 0.011V_o$$

$$\underline{n_o^2} = 0.089V_o \qquad \underline{n_o^3} = 0.010V_o$$

$$\underline{m_o^2} = 0.010V_o \qquad \underline{m_o^3} = 0.005V_o$$

These equations determine the structure (i.e. the proportions) of the educational system as well as its absolute level. Supposing the year 1966 as the base, the values of the educational factors of Iran have been calculated for three consecutive periods.

---

1. Refer to appendix ** for calculations of the coefficients.

BALANCED GROWTH OF THE EDUCATIONAL SYSTEM OF IRAN
FOR 68 PERCENT GROWTH PART PER 6 YEARS

Production in millions of dollars* population in thousands.

Symbols	Variables	TIME PERIOD 1966 (Real)	1966 (Estimated)	1966-72	1972-78	1978-84
V	Volume of production	6840 (1)	6840.0	11491.2	19305.2	32432.7
N^2	Manpower with secondary education	174.3 (2)	171.0	282.3	482.6	810.8
N^3	Manpower with third-level edicat-opm	53.2 (3)	75.2	126.4	212.4	356.8
n^2	Students in secondary schools	595.7 (4)	608.8	1022.7	1718,2	2886.9
n^3	Students in third-level education	36.7 (5)	68.4	114.9	193.1	'324.3
m^2	Manpower with secondary education and under 6 years employment	-	68.4	114.9	193.1	324.3
m^3	Manpower with third-level educat-ion and under 6 years employment	-	34.2	57.5	96.5	162.2

Sources: (1) Ministry of Economy, Statistics Bureau Report, Tehran (1968).
(2) and (3) Iran Statistical Center (12).
(4) and (5) Ministry of Education

* 1 Dollar = 75 Rials.

COMMENTS AND CONCLUSION

In the course of economic development, there seems to be a growing tendency towards manpower and educational planning. In order to have the various kinds of qualified, skilled or trained labour available at the right time and in the right numbers to ensure the society's development, having an education plan is inevitable. The essential problem is thereafter how to gear education to the requirements of society.

Fortunately, in handling the problem, some celebrated approaches have been done from which, one of the most dominant one i.e. that of Professors Tinbergen, Correa and Bos was examined in this paper. Their method of approach has been considered extremely valuable, but since that method essentially consists in assuming given rates of economic growth and of finding a unique set of "education requirements" corresponding to each of them, it has the great virtue of being simple and open to some fundamental objections.

We had the occasion to discuss some of these problems in the paper, and a chief drawback of this approach raised by some pioneers in the field is the problem of measurement in such an econometric approach.

It has been questioned whether it is fair to measure educated manpower just by adding the number of individuals with only subdivision being that of secondary and third-level education. Professor Bombach says that: "if no further subdivision is made between professions and occupations, I would say: no."[1]

The next measurement problem is the bias in the age pyramid in favour of younger groups. It has been said that it should perhaps be attempted to take into account

---

1. Comments on the paper by Messrs Tinbergen and Bos, [4], p.174.

the fact that young people just out of education institutes are equipped with more modern knowledge than the members of the previous generations. There exists, here, another argument by Professor Sen [18] saying that: "the Tinbergen approach concentrates completely on formal education without any weight being placed on the process of learning while at work. This is probably derived from an analogy with physical capital, but unlike machines, men do learn from experience. The rental of machinery tends to decline uniformly with age, but precisely the opposite is true of human beings for quite a while after they join work.[1] Therefore it seems necessary that such factors be mechanically analyzed."

Regardless of all supposed deficiencies of a model of this kind, which is relatively easy to sum up but more difficult to replace them by improved ones, we owe a debt of gratitude to professors Tinbergen, Correa and Bos for formulating rigorous models which have cleared the ground for further students.

1. See H.S. Houthakker, "Education and Income," [9]and G.S. Becker [2].

APPENDIX

* The values of μ^{21} , μ^{22} , μ^{3} in the case of Iran have been calculated as follows:

$$\mu^{21} = \alpha^{2}\delta^{2}$$

$$\mu^{22} = \alpha^{2}\sigma$$

$$\mu^{3} = \alpha^{3}\sigma^{3}$$

Where α^2 and α^3 stand for percentage of employable labour forces with a secondary and a third-level of education respectively. The values of these percentages in Iran are :[1]

$$\alpha^{2} = 0.80$$

$$\alpha^{3} = 0.90$$

δ^2 and o^3 stand for the ratios between the number of graduates during a period of time and the number of students enrolling at the educational institutions (high-school and third-level respectively). These ratios for Iran are estimated:

$$\delta^{2} = 0.47$$

$$\delta^{3} = 0.97$$

σ stands for the percentage of the students who do not continue their third-level of education during a period of 6 years with respect to the total number of students enrolling at a third-level of education at the beginning of that period. In order to calculate σ, the following formula has been used:

---

1. Economic Bureau, plan Organization, Iran.

$$\sigma = 1 - \delta^3 + (\gamma - 1)\frac{n^3_t}{n^3_{t-1}}$$

Where γ stands for the ratio of new enrollment at third-level institutes during a 6 year-period to the number of graduates from them in the end of that period. The value of γ has been calculated for Iranian educational system: $\gamma = 1.14$

Putting the equivalent values of parameters to the formula we will find the value of $\sigma = 0.014$.

Finally, we find:

$$\mu^{21} = \alpha^2\ \delta^2 = 0.80\ .\ 0.47 = 0.38$$

$$\mu^{22} = \alpha^2\ 6 = 0.80\ .\ 0.014 = 0.011$$

$$\mu^{3} = \alpha^3\ \delta^3 = 0.90\ .\ 0.97 = 0.87$$

** Coefficients of the condition equations which make the structural relations (i.e. the proportions) of the educational system have been calculated as follows:

Supposing t = 1, from equation (1.b) we have:

$$N^2_1 = 0.025V_1$$

By substituting the assumptions of the time path of growth:

$$(1.b)'\ \underline{N^2_o}\ .1.68 = 0.025V_o\ .1.68$$

$$\text{or} \quad \underline{N^2_o} = 0.025V_o$$

From equation (2.b):

$$N^2_1 = 0.989\underline{N^2_o} + m^2_1$$

Or

$$(2.b)' \quad N_o^2 \, . \, 1.68 = 0.989\underline{N_o^2} + \underline{m_o^2} . \, 1.68$$

Or

$$\underline{m_o^2} = 0.010V_o$$

From equation (3.b):

$$m_1^2 = 0.38\underline{n_o^2} + 0.011\underline{n_o^3} - n_1^3$$

Or

$$1.68\underline{m_o^2} = 0.38\underline{n_o^2} + 0.011\underline{n_o^3} - 1.68\underline{n_o^3}$$

Substituting the value of m_o^2 in terms of V_o into (3.b):

$$0.017V_o = 0.38\underline{n_o^2} - 1.67\underline{n_o^3}$$

Or

$$(3.b)' \quad \underline{n_o^2} = 0.045V_o + 4.4\underline{n_o^3}$$

From equation (4.b):

$$m_1^3 = 0.87\underline{n_o^3}$$

Or

$$\underline{m_o^3}1.68 = 0.87\underline{n_o^3}$$

Or

$$(4.b)' \quad \underline{m_o^3} = 0.518\underline{n_o^3}$$

From equation (5.b):

$$N_1^3 = 0.982\underline{N_o^3} + m_1^3$$

Or

$$1.68\underline{N_o^3} = 0.982\underline{N_o^3} + 1.68\underline{m_o^3}$$

Or

$$(5.b)' \quad \underline{m_o^3} = 0.415\underline{N_o^3}$$

From equation (6.b):

$$N_1^3 = 0.008V_1 + 0.03n_1^2 + 0.07n_1^3$$

Or

$$1.68\underline{N_o^3} = 0.008(1.68V_o) + 0.03(1.68\underline{m_o^2}) + 0.07(1.68\underline{n_o^3})$$

Or $$(6.b)' \quad \underline{N_o^3} = 0.008V_o + 0.07\underline{n_o^3}$$

By substituting the equivalent values of $\underline{n_o^2}$ and $\underline{n_o^3}$ from previous equations into equation (6.b)´ we find:

$$\underline{N_o^3} = 0.011V_o$$

Hence, the values of the other variables in terms of V_o could be found easily. Substituting the value of $\underline{N_o^3}$ into equation (5.b)´ :

$$\underline{m_o^3} = 0.415(0.011V_o)$$

Or

$$\underline{m_o^3} = 0.005V_o$$

By substituting the value of $\underline{m_o^3}$ into equation (4.b)´ :

$$0.005V_o = 0.518\underline{n}_o^3$$

Or

$$\underline{n}_o^3 = 0.010V_o$$

And finally by substituting the value of $\underline{n}_o^3$ into equation (3.b)´ :

$$\underline{n}_o^2 = 0.045V_o + 4.4(0.010V_o)$$

Or

$$\underline{n}_o^2 = 0.089V_o$$

REFRENCES

(1) BALOGH, T., "Comments on the paper by Messrs Tinbergen and Bos," *in The Residual Factor and Economic Growth,* O.E.C.D., Paris , 1964.

(2) BECKER, G.S., *Human Capital,* New York, 1964.

(3) BLAUG,M., *An Introduction to the Economic - of Education,* England, 1970.

(4) BOMBACH,G., "Comments on the paper by Messrs Tinbergen and Bos, "in *The Residual Factor and Economic Growth,* O.E.C.D., Paris, 1964.

(5) CHENERY, H.B., "Patterns of Economic Growth, *American Economic Review,* (September 1960).

(6) CORREA, H.& TINBERGEN,J., "Quantitative Adaptation of Education to Accelerated Growth, "*KYKLOS,* Vol. XV (1962) PP.776.

(7) DOMAR, E.D., *Essays in the Teory of Economic Growth,* New York, 1957.

(8) HARROD, R.F., *Towards a Dynamic Economics,* London, 1956.

(9) HOUTHAKKER, H.S., "Education and Income, "*Review of Economics and Statistics,* February 1959.

(10) INAGAKI,M., *Optimal Economic Growth: Shifting Finite Versus Infinite Time Horzon,* Amsterdam, 1970.

(11) IRAN, *Annual Report and Balanced Sheet* (as of March 20,1972), Bank Markazi Iran (Central Bank of Iran).

(12) IRAN, *Report of the Population Census,* Vol, 167, Iran Statistical Center, Esfand 1346, (February 1966).

(13) IRAN, *Education Statistics of Iran,* Ministry of Education, Tehran, 19E6.

(14) KALDOR, N. & MIRLEES, J.A., "A New Model of Economic Growth" *The Review of Economic Studies*, June 1962.

(15) MARTENS, A., *A Model for Planning Manpower and Education-Progress Report: The Structure of the Model* Montreal: International institute of Quantitative Economics, Pub. No.1, July 1969.

(16) MARTENS, A., STELCHER, M., & THONSTAD, T., *A Model for Planning Manpower and Education in Quebec - Progress Report 2: Student Flows Through Primary and Secondary Schools in Quebec*, Montreal: International institute of Quantitative Econcmics, Pub. No. 1, July 1969.

(17) SAMUELSON, P.A., "Parable and Realsim in Capital Theory:The Surrogate Production Function" *The Review of Economic Studies* June 1962.

(18) SEN, A.K., "Comments on the Paper by Messrs Timbergen and Bos," in *The residual Factor and Economic Growth*, O.E.C.D., Paris, 1963.

(19) SOLOW, R., "Technical Change and the Aggregate Production Function, "*Review of Economics and Statistics, 1957*.

(20) TINBERGEN, J. & BOS, "A Planning Model for the Educational Requirements of Economic Development," in *The Residual Factor and Economic Growth*, O.E.C.D., Paris 1964.

(21) TINBERGEN, J. & BOS, *Mathematical Models of Economic Growth*, New York, 1962.

(22) TINBERGEN, J., *Development Planning*, Trans. N.D. Smith, New York, 1967.