INVESTMENT IN EDUCATION: AN ECONOMIC POLICY DECISION PROBLEM

by

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CHAPTER I

INTRODUCTION

With the great majority of mankind in poverty and economic distress, with millions of people homeless and starving, it becomes important that careful consideration be given to the field of development economics: the study of those policies, decisions and actions which when implemented will bring about an optimum rate of economic growth when consistent with the institutional and technical limitations of the country.

The "revolution of rising expectations"--people demanding a greater share of economic goods and a better material well-being--is now on the march, developing in full momentum, with uncertain and, as yet, unforseen results. The recent concern of the more economically advanced nations and international bodies in the economic growth of underdeveloped lands is an indication of the importance attributed to these developments.

Revolutions and instability on the greater part of the globe will continue as long as poverty resulting from the long ages of economic stagnation prevails among the majority of mankind. With the growing awareness of the interdependence of the modern world, we must realize that our prosperity, peace and security are in the long run a common cause for all mankind. The future becomes a common concern. Hugo Munsterberg in a penetrating writing on America reminds us that it is not race or tradition that binds the American to his countrymen, but rather the future which Americans are building together. It is this future that Americans see and should more so conceive to be built in collaboration with all nations.

The complex reality of our economically divided world is put forth well by Robert Heilbroner, when he wrote that:

> The whole turbulent drama of the economic evolution has been confined to a fraction only of the earth's surface, and during this period of the evolution, to countless millions of Chinese, Indians, Arabs, Africans or South American peasants, the nations of fluid and dynamic economy in which a great drain of transactions bound together man and man, has never been anything but a tangential curiosity--strange, disturbing and often exploitative.(3, p.284)

The field of economic development is today the greatest frontier and challenge the world and, certainly, economists face. It is so, because of what it can provide to the underprivileged masses of the world and also because economic progress becomes the foundation upon which other more abstract hopes of mankind can come forth and be more effectively realized. Such hopes are international law and order, peace and security, that must become a heritage for all.

I have undertaken to deal with the problem of economic development. My purpose is twofold. First, I propose a way out of the stagnation dilemma and a breaking of the "vicious circles" so common in underdevelopment. This is done after a brief presentation and evaluation of the prevailing conditions in underdeveloped countries. Secondly, a demonstration is given as to how scientific method,[1] by the use of mathematical models, can be effectively utilized in economic development if the goals that we are after are to be attained through the available means; in our case it is shown how income and consumption can be maximized when using two different kinds of investment as our instruments. I deal with the problem as one who is interested only in the broadest structure of essential facts and causal relations, not in particular cases. Some interesting conclusions come forth from this analysis, though admittedly out of a very generous abstraction from economic reality.

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[1]The term "scientific method" is here taken to mean the making of economic decisions based on systematic knowledge acquired by careful observation and classification of facts.

These conclusions are based partly on my readings in development economics and partly on some mathematical derivations. The mathematical model is intended to serve as an illustration of the preceding verbal reasoning.

CHAPTER II

ECONOMIC DEVELOPMENT

Economists and the Challenge of Economic Development

The main thesis of this report is that human investment is a necessary prerequisite for economic development. If Y is a country's output and E is the level of education, measured by the average number of years spent in school per citizen, then $Y = f(E,K)$, where K includes all other variables on which Y depends.

Mr. Eugene R. Black, until recently, president of the International Bank of Reconstruction and Development, in preparing a bank advisory service, stated:

> Our experience continues to confirm that shortage of capital is not the only, and indeed not the principal obstacle to more rapid economic progress in less developed countries. Inexperience, the lack of trained manpower at every level are even more serious handicaps. (13)

Traditional economics has not much to say in the area of human investment. This is probably because in the humanistic West it was thought not appropriate to treat people as capital, or more so, because a stage of institutional reorganization involving basic educational investment came in the West long before economic science in the form of well-organized economic theories. As a result, such an investment was not treated in the light of economic reason. As a consequence of this, the economists have concentrated more on the effects of the economic order in their policy considerations and

failed considerably to examine the causes. That is to say, traditional economics accepted the institutional climate and worked from there on to the development of economic theory. Such an approach is almost meaningless in today's underdeveloped countries.

The emergence of new nations offers to the economist a great new challenge for original and creative thinking. Such a challenge becomes more important when it is realized that on the economic growth and the material well-being of the now impoverished majority of mankind, the security, stability and peace of the entire globe depends. I must admit that our concern in human investment brings the economist to a delicate position on a subject that involves value judgments and pronouncements not traditionally accepted in the profession. But such a consideration is made necessary because of the special conditions encountered in underdeveloped economies today.

The Prevailing Conditions in Underdeveloped Economies

A unique and different state of affairs than the one encountered in developed economies prevails in underdeveloped countries. It is not my purpose here to give a detailed account of the problems and promises of development. The interested reader, for an up-to-date report on the subject, is referred to Paul Hoffman's writings in Encyclopaedia Brittanica's, Book of the Year, 1962. (11)

As the many problems are faced in the actual development of countries, differences among the countries must be taken into consideration. But the attack on poverty, hunger, illiteracy and chronic ill-health can be understood against the background of certain common denominators of underdevelopment. These common denominators are:

1. Shortage of capital.
2. Inability to increase export earnings to pay for essential imports.

3. Lack of productivity.
4. Lack of knowledge of physical resources.
5. Lack of trained people to bring resourses, physical and human, into effective use.
6. Lack of organized programming and planning for development.
7. Social, psychological and religious attitudes which hamper development.
8. Rapidly expanding populations.

Evaluation.--A careful examination of the conditions stated above and prevailing in underdeveloped economies, should convince us of the validity of the main thesis of this report. As stated earlier, ". . . human investment is a necessary prerequisite for economic development." The quantity of "other investment" (investment other than in education) is greatly limited by the special conditions encountered in underdeveloped countries. The lack of what we can inclusively call "economic sophistication" or "climate of growth" allows only the minimum of "other investment." Investment, then, in the human element, investment in education in the broadest sense, is the initial and basic need. Such an investment, if it is to accomplish the desired results, requires a clear understanding of the problems and potentialities of economic development. It requires, especially, an adequate understanding of the different conditions encountered in the new countries. The economist cannot afford to look at the past alone for guidance. New and creative thinking is necessary to meet the new realities that confront his profession in the new nations.

The Need for a Proper Climate Conducive to Economic Growth.--Before traditional economic analysis can be applied so that economic growth may take place, the proper climate must have developed. A climate with the proper psychological, ideological, social, religious and political set-up must come about, including new developments in the field of health to prolong the productive healthy years of the population. Economic theory, then, should aim to develop that national and international climate conducive to economic growth. This new "climate" will inevitably require the destruction and

dissolution of social and cultural patterns in the developing country, so that economic logic, both in theory and in practice can work. In the words of Alvin Hansen, "Economic development requires emancipation from tradition." (2, p.159)

This "climate of growth" can be brought about by various means. It is here suggested that this be done through education--an attempt to control the vast forces that the urge for economic growth brings about, rather than leave them to obey their own uncontrolled momentum, which leads either to chaos or to communism.

Educational Investment

My contention is that any theory of growth must explicitly deal with educational investment, and the failure to explicitly express it as such will result in a theory by no means complete or adequate. It is not enough to state the need of entrepreneurship or efficiency or technology, as a great number of theories in economic development do. Such variables assume an "economic climate" which we suggest is non-existent in the economies under consideration. In the words of Gunnar Myrdal:

> Economic theory has disregarded the so-called noneconomic factors and kept them outside the analysis. As they are among the main vehicles for the circular causation in the cumulative processes of economic change, this presents one of the principal shortcomings of economic theory. . . . It explains largely why this theory was unable to state the dynamic problems of economic underdevelopment and development--or to formulate it differently, how this theory managed to avoid stating these problems. (6, p.30)

It is suggested that the growth model treat the educational investment as a variable of great and immediate significance. The educational investment during the "take-off" stage, to borrow W. Rostow's terms (8), is the prime variable of concern, and it is through the recognition of its importance that we can expect further and faster economic growth.

A Central Obstacle to Economic Growth

Vicious Circles of Underdevelopment.--The "road to development is paved with vicious circles."(4) Take for example the prevailing low productivity in agriculture and the under-employment in that area (the condition where the farmer is productively employed only a small part of the year). Such a situation reflects the fact that the farmer has no other alternative but to stay on the farm. Capital is needed to develop labor-incentive industries so as to absorb the unemployed farmer and raise the productivity on the farm, but the capital is lacking, and unless the farms produce enough so that money can be saved for investment, the economy remains stagnant. Vicious circles of this kind are the rule and not the exception in underdeveloped economies, with certain patterns being both the cause and the result of an existing and undesirable situation. C. E. Wilsow expresses his observations on the subject in the following manner. He says:

> It was clear . . . that poverty and disease formed a vicious circle. Men and women were sick because they were poor; they became poorer because they were sick, and sicker because they were poorer."(10, p.9)

It is here suggested that a low educational standard is the fundamental cause of economic stagnation at a low plateau. A low educational standard causes low productivity, health deficiencies and low earnings, and these in turn keep down the educational standards, and so on.

In economic underdevelopment, every possible stagnation can be thought of as the result of vicious circles of the nature here discussed. Albert Hirschman has recently added that, ". . . some circles are more vicious than others."(5) The task then is to discover these vicious circles that can be seen as the basic causes of the country's economic stagnation and suggest ways through which we can break into them. The proposal is here made that the breaking point comes when the need for human investment is met.

Further, I suggest that if we allow a stagnant economy to obey its own momentum there will be no change and no economic growth. In terms of Newtonian symbolism, the economy moves with the same velocity and no acceleration or a decrease in velocity and deceleration. The vicious circles that cause such a stagnation cannot be broken by the existing internal mechanisms in the underdeveloped country. The solution--breaking of the vicious circles--should be sought elsewhere. In the pages that follow, the suggestion is made as to the nature of the solution needed. Such a solution is sought outside the underdeveloped economy--by an outside force.

A Mathematical Analogue.--In mathematical and mechanical language we can think of the stagnant economy as if moving at a uniform motion on a straight path with no acceleration. Without outside intervention such an economy maintains a uniform motion in the same original direction. It takes an outside force acting on such an economy to bring about the desired change in direction and/or velocity.

CHAPTER III

ECONOMIC DEVELOPMENT: AN INTERNATIONAL RESPONSIBILITY

An International Agency for Development

The Interdependence of the Modern World.--The world is here seen as one entity, as one economic community, with each member having a vested interest in the welfare of the other. The economic, scientific and technological achievements of the rich countries are a common heritage to all humanity. It will be interesting to examine why certain countries are economically well off and others are not. National boundaries are as irrationally drawn, in terms of economic considerations, as the boundaries of African tribes. It is irrational to isolate one region of the world from the other--to rich

and poor countries. History and historical experience become today a global, not a national concern. In a few hours one can travel from London to Timbouctou, yet the difference in living standards between the two is alarming indeed. The economist, if he wants to be successful in his theory as well as practice, must account for the new realities and see the world in its global concord.

Transfer of Knowledge and Skill.--Some nations are lucky enough to have found themselves the prime beneficiaries of the western heritage, which made an effective use of the scientific method. These nations have an obligation, if to nothing else to their own survival, to see that a successful adaptation of their methods be achieved in the underdeveloped world. It is understood that any attempt in applying the scientific method as developed by western thought will necessitate interruptions and changes in the cultural and social patterns of the underdeveloped country. But it is suggested that the break of the vicious circles and the impact of change when brought about via the educational investment, will avoid any chaotic disruptions of the social order or resignations from any effort on the part of the native populations. This is at a time when motivation and action are the foundation of the "leap forward" in the process of economic growth.

We then seek to transfer and adopt the scientific and technological methods of the West in the other countries. This in itself will help, but not all that logically follows from the assumptions made must be expected. Very often our assumptions are not realistic. Science is not simply knowledge. Especially in developing economies, science becomes an attitude toward the physical universe. That is why the economic climate is more important than the economic technique.

It must be clear by now that the task in providing the initial economic momentum and leading a country out of the economic dilemma of stagnation must

be an international concern. The initial assistance must come from outside the country. The way out of economic stagnation (the endless vicious circles encountered in economic underdevelopment) is via a successful application of the scientific method. Such an application will be realized when the proper climate develops in the stagnant economy. It is proposed that the "proper climate" develops through the right kind of education. This education requires investment both in capital and primarily in skill from outside the developing country. It has to come from outside if economic growth is to be considered at all. Economic development must then become an international concern. These statements are generalizations, as a "theory" in economic development is permitted to be. Such a theory should encompass socio-economic facts and organize them into a pattern, viewed under a broad perspective. The whole of the first part of this report is an attempt to rationalize economic development from the economic point of view. This pattern is a summary of my observations in developing countries such as Greese, Southern Italy, Cyprus and Israel, as well as my reading on the subject.

In education, then, with an outside source providing the educational investment, we must seek the way out of the stagnation dilemma. The autonomous investment or resource discovery discussed by Hansen and others is here seen as greatly facilitated from outside the stagnant economy. This investment brings about the needed change for economic growth to take place by adaptation rather than by innovation or new inventions.

The International Agency.--I propose here, an International Agency (hereafter referred to as the Agency) to carry out the task in the initial stages of economic growth. Such an Agency will have the power and responsibility to formulate and implement the development policy. It is understood that the Agency, in cooperation with an existing or appointed national planning board, constitute the Executive Agency in the initial stages of development

and the breaking down of the vicious circles. The planning period will probably require the active participation of the Agency for a couple of decades in the country's economic development. Current, short-run economic plans will be treated as part of long-run economic planning. Investment in education is the prime concern of the Agency; such an investment is, of course, not an isolated act in the economic policy; it must be concurrent with other investments in resource discovery, geological studies, population problems, railroads, harbors and tax systems. This fact is expressed in our economic model in Chapter IV of this report. What must be kept in mind is that in the early years of the economic development process the center of attention must be investment in the human element, which will bring about that presently-lacking climate conducive to economic growth.

The idea of an International Agency for development as here suggested may sound rather idealistic and not a very realisitc proposal, but in effect it is nothing more than a means to synthesize, systematize and effectively utilize the many fragmented and often inconsistent efforts of economic development through foreign aid. The Agency will complement and coordinate all the present unilateral efforts and fractional programs of the specialized agencies of the United Nations and variety of governmental agencies dealing with economic development. It can be argued that such an Executive Agency is impossible given the present state of the cold war. Nevertheless, economic cooperation in the present international bodies has been maintained, at a reasonable level, between East and West. Further, a close and objective examination of the East-West ideological issues will reveal a great degree of similarity in the materialistic side of the philosophies of the two camps. World development during the past half century should have made us aware that nothing is permanent--particularly not the political developments in various countries

and their arrangement in different camps according to ideologies. Memorable will be my touring of West Berlin this past summer (summer of 1962). The city was completely rebuilt by generous American capital. The irony of the situation is that the same city of Berlin was almost completely destroyed by "generous American capital" not long ago! I suggest that the near future keeps not a few surprises for us in seeing the unexpected happen in international cooperation and understanding. Economic and political history teaches us that the today's complexities soon become the tomorrow's accepted reality.

Political, economic and technical reasons should also prompt international action and justify the proposal of the International Agency as here conceived. For example, representatives of countries receiving assistance repeatedly declare their general preference for help given through the United Nations--an international agency--because aid from such a source is not politically motivated. Further, such an assistance will be a completely cooperative venture, with a voice given to all concerned. On the other hand, the Agency can be firm and rational without being accused of seeking any political or commercial advantage. Such an Agency will unite the strength of all nations in the titanic effort of economic development.

In many economic and mainly political sectors in the advanced countries, especially the United States of America, it is argued that the private sector through "free enterprise" should steer economic development. The proposal of an international agency which, in cooperation with the new governments assumes responsibility both as a planning and executive agent, in the development process, will be criticised by such "free enterprise" worshipers as interfering with the market forces. Such a criticism is the outcome of a sentimental wish far removed from serious economic thinking and derives primarily from a mistaken evaluation of the state of affairs in underdeveloped

lands. It will be an immature gesture of illwill on our part to allow slogans of "laissez-faire" capitalism and "free enterprise" to weaken rational thinking and constructive theories that can bring about economic development when and where it is needed. It will be mischievous to play with slogans, the poverty and the distress of three-fourths of mankind, while sitting comfortably in academic and ideological isolation, looking out from the dim window of an abundant and affluent society. It is sad to hear the many irresponsible statements made by a loud sector in the advanced countries such as, "They are going socialist," "Shut out any foreign aid," and the like. This, especially when so much in economic development depends on the attitudes and policies instituted by the advanced countries.

CHAPTER IV

A SIMPLE GROWTH MODEL

Economic Models: An Approach to Economic Development

This part of the report deals briefly with economic models. In doing so I borrow heavily from Jan Tinbergen (9) and the Netherlands experience in economic planning and models (1). An economic model can be described as a simplified picture of economic reality, presented by a list of phenomena and variables casually related, and expressed by a system of simultaneous mathematical equations. In other words we can define a model as a set of equations in a number of variables, postulated from economic theory.

Economic models can render great assistance to economic development. At best economic development policy consists of the deliberate variation in certain available means or instruments in order to attain certain aims. The main problem, then, is finding out the limitations in the general theory and

revealing inconsistencies in the development plan so that we can best derive the necessary modifications in formulating our economic policy. A serious limitation in the use of models in underdeveloped countries is the fact that accurate statistical data are often lacking; as a result, as well as because of the simplified nature of models, differences will be found between econometric prediction and actuality. What is decisive, however, is not that models are not erring, but the fact that a more efficient development policy can be pursued with models than without them. It is suggested that with models a certain hold is obtained in development policy and forecasting which would be lacking without the use of models. Prior to 1950, few economists would have held out much hope of achieving useful models of complete economies, where models could describe the everyday economy with an accuracy that would suit the needs of decision makers. Today a considerable number would be optimistic about this. Recent developments in econometric and computer techniques have set the stage for dramatic improvements in the model study of complete economies.

The model proposed here is more of a pedagogical character. It illustrates some general theoretical points about an underdeveloped economy, as put forth in the first chapter of this study. Emphasis is given to the method rather than on the practical application of the model. Models of exact and practical natures have been worked out. As an illustration of these, a more enlarged form of the present model is included in Appendix A (Pg.20) Educational and other investment are controlled variables referred to as the instruments of economic policy.

The Model

Equations

(1) $X_{t-1} + x_t = X_t$

(2) $Y_{t-1} + y_t = Y_t$

(3) $u_t = g X_{t-1}^{a} Y_{t-1}^{b}$, $a > b > 0$, $g > 0$.

Constrairts

(4) $u_{t-1} = x_{t-1} + y_{t-1}$

(5) $x_t > 0$

(6) $y_t > 0$

All quantities are greater than zero.

Symbolism

u_t = national product during period t after depreciation and subsistence consumption are taken out.

x_t = net investment in education during period t.

X_t = educational capital stock at the end of period t.

y_t = net other investment during period t.

Y_t = other capital stock at the end of period t.

g = productivity coefficient.

Explanation of equations.--Equations (1) and (2) express the accounting fact that the present year's capital stock is the sum total of last year's stock plus this year's net investment. Equation (3) is the Cobb-Douglas production function (6). Coefficients a and b are elasticities of output with respect to the input of capital (and indirectly, therefore, of net investment x_t and y_t). We observe from equation (3) that both capital inputs (X_{t-1}, Y_{t-1}) are required if output (u_t) is to be non-zero. Note that the labor input is not brought into the equation explicitly. Labor is assumed

always to be applied and the coefficient relates labor to output. Constant full employment is assumed throughout in the economy.

The problem.--Given the model, and given X_0 and Y_0, to select values of $x_1 \cdot \cdot \cdot x_{t-1}$ and $y_1 \cdot \cdot \cdot y_{t-1}$ so as to maximize u_T, where T is the final period (year).

In other words, with a given educational and other stock at hand, we want to select educational and other investment during successive time periods so as to maximize the national product at a final period T.

Theorem.--(Proof given in Appendix B) The national product at the final period, u_T, is a maximum subject to (4) (t = T), if and only if u_t is maximized subject to (4) for each t = 1 . . . T-1, when given X_{t-2}, Y_{t-2}.

This theorem reduces a complex multi-period optimization problem to one of optimal investment "policy" to be followed consistently in each time period. An illustration is presented in the next section.

Hypothetical Investment Policy: A Numerical Example

It is shown in Appendix B that, as a result of this theorem, the optimal investment policy (needed to maximize u_t in each year) is to select the two kinds of investment according to the formulas

$$x_{t-1} = \frac{a}{a+b}(u_{t-1} + X_{t-2} + Y_{t-2}) - (X_{t-2})$$

$$y_{t-1} = \frac{b}{a+b}(u_{t-1} + X_{t-2} + Y_{t-2}) - (Y_{t-2})$$

What follows is a numerical solution of the previous simple investment model. The policy decision problem is to select x_t and y_t for seven successive years, so as to maximize the country's output in the eighth year.

In light of the previous theorem and the solution derived in Appendix B, we must select $x_1 \cdot \cdot \cdot x_7$, $y_1 \cdot \cdot \cdot y_7$, in such a way that $u_1 \cdot \cdot \cdot u_7$

is maximum in every period $t_1 \ldots t_7$. Then u_8 will be maximum as desired. The side constraint on our model remains as $u_{t-1} = x_{t-1} + y_{t-1}$. X_o and Y_o are given.

Given $X_o = 16$, $Y_o = 13$, $a > b > 0$

$a + b = 1$
$a = 0.6$
$b = 0.4$
$g = 0.5$

All variables are at each time period greater than zero.

We have: $u_t = g X_{t-1}^{a} Y_{t-1}^{b}$

The numerical results of this problem are tabulated in Table 1 below, where the optimal schedules of investment, capital stock and national product are given over the eight time periods.[1]

Table 1. Optimal Schedules of Investment, Capital Stock and National Product Over Eight Time Periods

Time Period	National Product	Investment		Capital Stock	
		Educational	Other	Educational	Other
t	u	x	y	X	Y
1	7.35	5.80	1.55	21.80	14.55
2	9.29	5.60	3.74	27.40	18.29
3	11.69	7.00	4.63	34.40	22.92
4	14.62	8.75	5.89	43.15	28.81
5	18.32	11.00	7.30	54.15	36.11
6	23.14	13.85	9.35	68.00	45.46
7	29.00	17.40	11.60	85.40	57.06
8	36.30				

Figures 1, 2 and 3 give a graphic representation of these numerical results. (See pp.27, 28 and 29)

[1]Note that because of rounding up the decimal digits and the exponential character of equation (3), the numerical solution is accurate to only one decimal digit. The following relations hold true: $\frac{X_t}{Y_t} = \frac{a}{b}$, $X_t = X_{t-1} + x_t$, $Y_t = Y_{t-1} + y_t$, $u_t = x_t + y_t$.

While the unit of measurement is arbitrary, it may be taken as billions of dollars.

Summary of results.--Educational investment x_1 to x_7 and other investment y_1 to y_7, must be as given above if we are to maximize u_8, which will be equal to 36.30. Any more investment will violate the constraint, and any less or any other ratio will fail to yield the maximum u_8 attainable.

CHAPTER V

CONCLUSIONS

With the realization of the greater interdependence of the modern world, it becomes important that careful considerations be given to the field of development economics. Careful analysis of the state of affairs in underdeveloped countries reveals that human investment is prerequisite for economic development. Such an investment cannot come from within the country alone, and international assistance is required. Economic development, then, becomes an international concern. A simplified mathematical model in incorporating these observations gives some interesting conclusions.

The model presented is hypothetical in nature, based on assumptions and observations that must be kept in mind while evaluating our conclusions. The reader is reminded of the generous abstractions from economic reality that we resort to. A complete description of the model will require the enumeration of a large number of variables and detailed equations. The model here states that national product may be assumed to depend primarily upon two kinds of investment, educational and other investment. It is understood that many other variables have an effect upon national product (u_t), but the two kinds of investment have the most prominent influence. Further, the theoretical assumption of the greater "efficiency" of educational investment as compared with other investment is expressed in the model and the numerical example that follows, by assuming the elasticity with respect to educational

investment as being greater than the elasticity with respect to other investment, b.

We can conclude:

(a) That the rate of growth of x_t, y_t, X_t, Y_t and u_t is at an increasing rate with respect to time (Table 1, Fig. 3, 4).

(b) The rate of educational investment x, must be greater than the rate of other investment y, if we are to maximize output in the final period (Fig.3).

(c) The marginal productivity of educational investment x, $\frac{\partial u}{\partial x}$, must in all time periods be equal to the marginal productivity of other investment y, $\frac{\partial u}{\partial y}$, when a final output is made a maximum.

(d) It was suggested in Chapter III that the need of international assistance is very urgent and necessary in the underdeveloped countries. We can see from our model that such an assistance in amount A could result in a higher national product (u_t), since our constraint would now be altered or,

$$A_t + u_t = x_t + y_t$$

(e) We can observe that u_t was assumed positive after depreciations and subsistence consumption were taken out. In accordance with the "vicious circles" type of stumbling blocks to development discussed earlier we can see that u_t can be zero. As a result investment cannot be realized from the internal country's mechanisms alone.

(f) It must be emphasized that constant returns to scale are relevant for periods and countries in which adjustment of x and y is possible. It is also understood that our investment is utilizing the country's resources to the normal optimum capacity. It is hoped that as the needs in educational investment are met and the country continues to expand the scale of its operations, increasing returns to scale ($a + b > 1$) may be realized. It can be suggested that the u curve over a longer run growth span might be of a logistic nature.

APPENDIX A

A TWELVE-EQUATION DECISION MODEL

The economic model we have dealt with in Chapter IV is of a simplified nature. It proved useful in illustrating some basic theoretical points for an underdeveloped economy. We showed how our economy tends to grow and something about the pace of growth, as well as how such a growth must come about by the optimum use of our two kinds of investment. However, such a model is not suitable for practical policy decisions, and it can serve only as the foundation for models that can more accurately describe the actual workings of the everyday economy so as to suit the needs of the decision-makers.

Several working models have been used in applied economic analysis. The interested reader is referred to (1) in the list of references. One example of a typical system, which is essentially an elaboration of our previous model, is given below. Export and import variables are incorporated in the model, as well as price variables. The introduction of prices makes it necessary to introduce money value variables in addition to physical quantity variables. Explicit differentiation of all prices is not made and all domestic goods are assigned the same price.

The Model:

i. Definitions

1. $E = P_e e$
2. $D = I - E$
3. $I = iZ$
4. $Z = C + S$
5. $Z = P_d u + E - I$

6. $X = X_{-1} + x$

7. $Y = Y_{-1} + y$

ii. Behavior equations

8. $C = C_o + m_1 Z + m_2 P_d$ Consumption function.

9. $P_d = c_1 u + c_2 P_i$ Supply function: domestic goods.

10. $e = e_o - n(P_e - P_w)$ Export demand.

11. $P_e = r_1 u + r_2 P_i$ Supply function: exports.

12. $u = g(X_{-1})^a (Y_{-1})^b$ Production function.

iii. Constraint on instruments

13. $\frac{S}{P_d} = x + y$

All variables are assumed to be positive. The subscript t is omitted for simplicity.

Endogenous variables:

These are variables which are determined by the relations of the model. Upon the solution of the model (solution of the simultaneous equations) a unique solution, as a rule, exists for every endogeneous variable. The model involving twelve equations and twelve endogeneous variables is referred to as a complete model. Definitions of the endogeneous variables follow.

e = volume of exports of goods.

u = volume of domestic goods above depreciations.

X = volume of educational stock.

Y = volume of other capital stock.

C = value of consumption

D = value of deficit in the balance of payments.

E = value of exports.

I = value of imports.

S = value of saving

$-$ = value of disposable income.

P_d = price of domestic goods.

P_e = price of exports.

Predetermined variables:

These are variables which are not determined in the model. They may be subdivided into the three types indicated below.

i. Instruments

x = volume of net educational investment.

y = volume of net other investment.

ii. Uncontrolled exogeneous

C_o = value of autonomous consumptions.

e_o = volume of autonomous exports.

P_i = price of imports.

P_w = price of competing goods in the world market.

iii. Lagged variables

X_{-1} = X for previous year.

Y_{-1} = Y for previous year.

Coefficients:

c_1 = inverted elasticity of supply: domestic.

c_2 = inverted elasticity of supply: exports.

g = productivity coefficient.

i = elasticity of import demand.

m_1 = propensity to consume

m_2 = domestic price elasticity.

n = price coefficient of demand: exports.

r_1 = inverted elasticity of supply: exports.

r_2 = exports price elasticity.

Concluding remarks:

A model of this type can be used in policy decision problems. Educational and other investment will be the instruments, the means used for the adaptation of the economy to the desired aims or targets. A target in this case can be to maximize real expenditure per capita during a final period T. Population is not a variable in our model and we assume it to be constant. The constraint on our investment in equation (4) shows the decision that must be made at every time between consumption and earning. An optimum output (u) is expected to maximize disposable income (Z) in equation (5). A maximum output (u) is attained with an optimum rate of saving that is invested, but the greater the saving and investment, the smaller is the amount left for consumption (C). It is here demonstrated that as the country shifts resources into the capital formation sector, more must be taken away from the consumption sector of our model economy. Since in underdeveloped economies living standards are already close to the margin of existence, the economy will not be able to transfer the necessary resources from consumption to saving and investment, so that the desirable goals could be achieved. This conclusion is a strong support to the thesis that outside help is urgently needed in the early stages of economic growth.

APPENDIX B

PROOF OF THE THEOREM ON PAGE SIXTEEN

We are to prove that, given X_o and Y_o, u_t is a maximum subject to (4), with t = T, if and only if u_t is maximized subject to (4) for each t = 1 . . . T-1, when given X_{t-2} and Y_{t-2}.

Consider first the following problem: Given X_{t-2} and Y_{t-2}.

(3) $u_t = g X_{t-1}^{a} Y_{t-1}^{b}$ to be maximized subject to

(4) $u_{t-1} = x_{t-1} + y_{t-1}$ or, when using (1) and (2), subject to

(7) $X_{t-1} + Y_{t-1} = u_{t-1} + X_{t-2} + Y_{t-2}$.

We observe from equations (1) and (2) that X_{t-1} and Y_{t-1} are nondecreasing functions since x_t and y_t are equal or greater than zero (note that if x_t and y_t are greater than zero then the functions are increasing).

From (3) we see that u_t is determined by X_{t-1} and Y_{t-1}. Since a and b are positive and X_{t-1} and Y_{t-1} are nondecreasing functions so is u_t. Further, u_t would be a maximum when X_{t-1} and Y_{t-1} are maximum for each value of t, subject to the constraint (4).

By Lagrange's method of finding the maximum of a function with constraints, we have:

$$L = g X_{t-1}^{a} Y_{t-1}^{b} - \lambda(X_{t-1} + Y_{t-1} - u_{t-1} - X_{t-2} - Y_{t-2}),$$

$$(8) \quad \frac{\partial L}{\partial X_{t-1}} = ag X_{t-1}^{a-1} Y_{t-1}^{b} - \lambda = 0,$$

$$(9) \quad \frac{\partial L}{\partial Y_{t-1}} = bg X_{t-1}^{a} Y_{t-1}^{b-1} - \lambda = 0.$$

By eliminating λ in (8) and (9) we have

$$(10) \quad \frac{a}{b} = \frac{X_{t-1}}{Y_{t-1}}$$

By solving equations (7) and (10) simultaneously for X_{t-1} and Y_{t-1} we derive necessary conditions for a maximum u_t subject to (4), (5), and (6); so that

optimal X_{t-1} and Y_{t-1} and optimal x_{t-1} and y_{t-1} are:

$$(11)\quad \hat{X}_{t-1} = \frac{a}{a+b}\,(u_{t-1} + X_{t-2} + Y_{t-2})$$

$$(12)\quad \hat{Y}_{t-1} = \frac{b}{a+b}\,(u_{t-1} + X_{t-2} + Y_{t-2})$$

$$(13)\quad \hat{x}_{t-1} = \frac{a}{a+b}\,(u_{t-1} + x_{t-2} + y_{t-2}) - (X_{t-2})$$

$$(14)\quad \hat{y}_{t-1} = \frac{b}{a+b}\,(u_{t-1} + x_{t-2} + y_{t-2}) - (Y_{t-2})$$

That is, equations (11) and (12)--or alternatively equations (13) and (14)--must hold for u_t to be to maximum at any t. From (11) and (12) we see that X_{t-1} and Y_{t-1} will be maximum when u_{t-1} is a maximum. But u_t will be maximum when X_{t-1} and Y_{t-1} are maximum. Therefore, for u_t to be maximum u_{t-1} must be maximum.

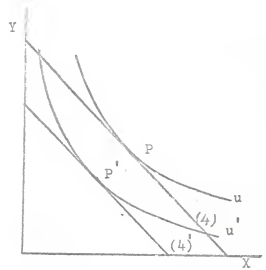
Before the proof is completed one logical issue still remains to be settled. The condition that $\frac{\partial L}{\partial X} = \frac{\partial L}{\partial Y} = 0$ is only a necessary condition for the existence of a maximum or minimum point. How do we then know that we have found the absolute maximum of L or a maximum of u_t subject to the constraint? A sufficient condition for the existence of an absolute maximum must also be satisfied.

We use a geometrical approach to the question.

1. The relative maximum of u_t subject to the constraint may be represented geometrically as the point of tangency of the constraint and the highest contour of u_t possible.

2. The contours of u in X and Y plane are hyperbolic-convex to the origin everywhere. (Fig. 4)

Figure 4



3. Equations $\frac{\partial I}{\partial X} = \frac{\partial I}{\partial Y} = 0$ yields a unique point in the X,Y plane. Hence, this point must furnish the desired absolute maximum.

Therefore, we can state that for each u_t maximum we can prove that u_{t-1} must be maximum. It follows that the previous statement is true for every positive integer t = 1 . . . T.

This completes the proof.

Figure 1

Expansion Path of a Hypothetical Underdeveloped Economy for Three Time Periods with Related Iso-Product curves and Investment Constraints

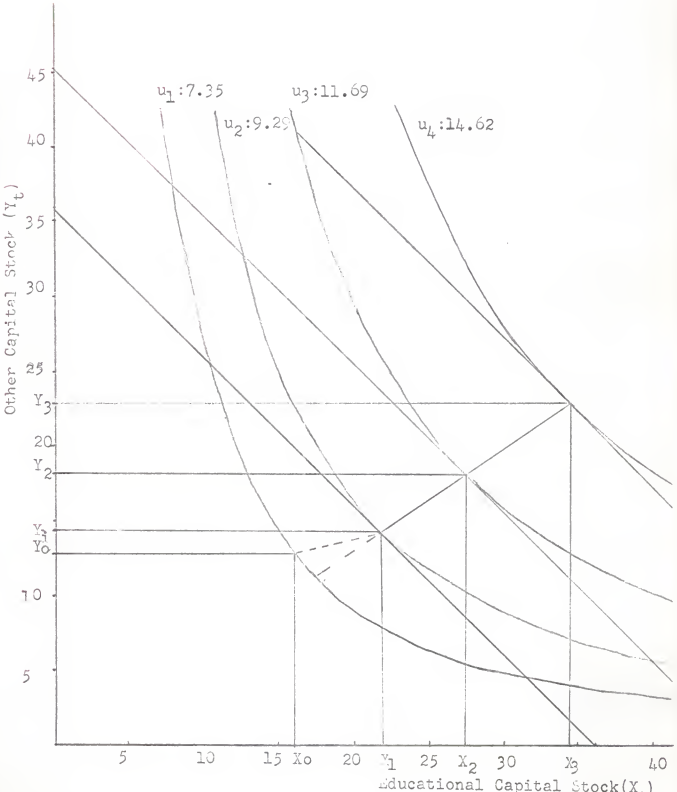


Figure 2

Educational and Other Investment and Product Expansion Path

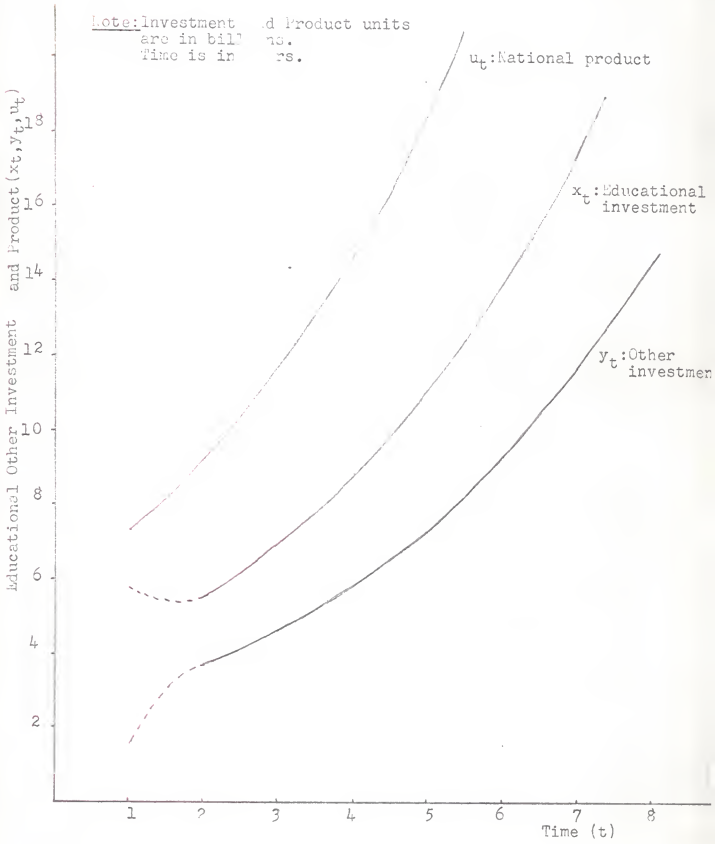
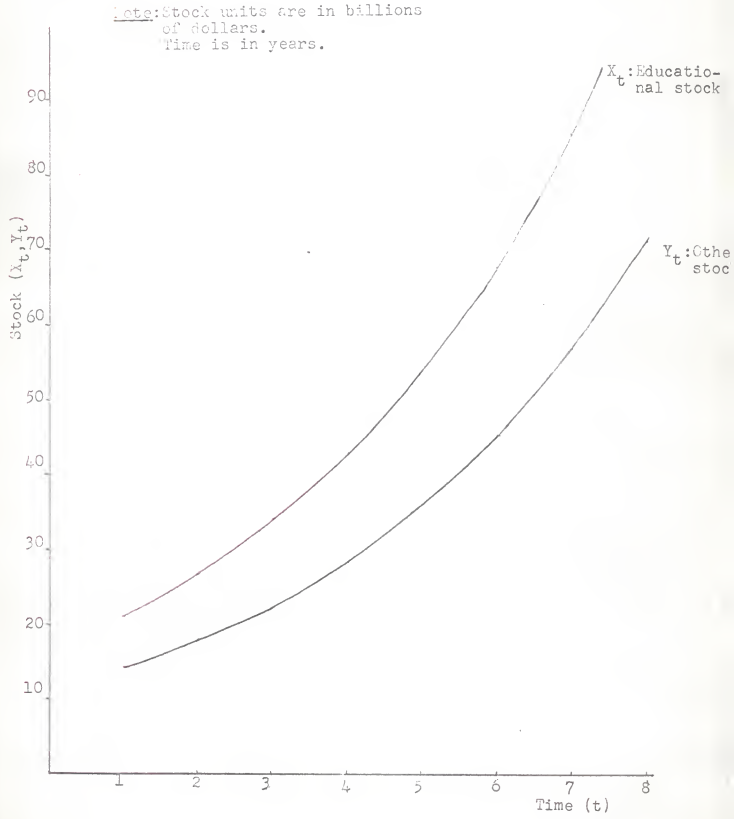


Figure 3

Educational and Other Investment Expansion Path



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INVESTMENT IN EDUCATION: AN ECONOMIC POLICY DECISION PROBLEM

by

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B. S. in Mathematics, Kansas State University, 1961

ABSTRACT OF A MASTER'S REPORT

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requirements for the degree

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KANSAS STATE UNIVERSITY
Manhattan, Kansas

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Economic growth in the underdeveloped areas of the world presents today a great challenge to the world and to economic science. Because of the interdependence of nations and at the same time the unjust divergence of living standards it is of importance that theories be developed which when applied will bring about a desirable rate of economic growth. On the successful economic development of the underdeveloped nations depends the peace and security of the entire world.

When carefully studying the prevailing conditions in underdeveloped economies, we confirm that inexperience, the lack of trained manpower, and in general the absence of an appropriate climate for economic growth are basic handicaps.

In economic development stagnation is the result of vicious circles that indefinitely perpetuate themselves. A low educational standard is the fundamental cause of such vicious circles and of economic stagnation at a low plateau. A low educational standard causes low productivity, health deficiencies and low earnings, and those in turn keep down the educational standards, and so on.

It is suggested that the task in providing the initial socio-economic momentum and leading a country out of the economic dilemma of stagnation must be an international concern. A proposal for an international agency for development is made. In the early stages of development a special emphasis should be given to investment in education. The central effort should be to transfer the advanced countries' knowledge and skill to the economically underdeveloped world. We can talk of an effective application of the scientific method, which is here taken to mean the making of economic decisions based on systematic knowledge acquired by careful observation and classification of facts.

A simple growth model is presented in the fourth chapter of the report, where educational (x_t) and other (y_t) investments are used as controlled policy instruments in maximizing national output (u_t). It is proved mathematically that given the model and conditions on the variables involved, output u_T at a final period is a maximum if and only if u_t is maximized at every previous period. A hypothetical investment policy is presented as a numerical example. The model illustrates the theoretical points discussed earlier in the report.

A more enlarged form of the model is also presented. It is shown how the use of mathematical models renders to the policy maker an effective tool which when intelligently used, based on the available knowledge, can help make the best decisions. In economics in general and development economics in particular, knowledge is useful as long as it helps us in making the best decisions.