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Evaluation Model of Technological Aid Policy to Developing Countries

by

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EVALUATION MODEL OF TECHNOLOGICAL AID POLICY TO DEVELOPING COUNTRIES

ABSTRACT

A mathematical model and the analysis procedures based thereupon are proposed to evaluate the policy for technological aid to the developing countries. This model may be considered mathematically as a generalization of Lotka-Volterra model, Gause model and Leslie-Gower model and has a more flexibility for stability and sensitivity analysis. This model may be useful in providing a foundation of energy or resource economics as representing the material flow in physical terms. The method proposed here is applicable even when the availability of data is limited and rather provides a tool for parameter estimation by generating various possible trajectories. This method is shown to represent and explain the complicated nonlinear relationship between the developed and developing countries in the decade around the oil-crisis. Hence it is expected useful in predicting the industrial behaviour, classifying the technological qualities in the devleoping countries and evaluating possible changes of policies.

Keywords. Linear differential equations; parameter estimation; stability; energy control; technological aid; appropriate technology.

1. INTRODUCTION

Evaluation of technological aid to the developing countries is not only a serious problem from a practical point of view but a challenging problem from a theoretical point of view. As the economic theory has been developed in and for the industrialized countries, behaviour and causality of industry in developing countries remain unclear and their data are unavailable. Our theoretical approach starts with the recognition of this fact and attempts to provide a tool for identifying them as well as a tool for theoretical analysis.

Several literatures are available regarding the developing economy or the economic relation with a developing country in general from a techno-ecnomic point of view [Baer (1976), Heal (1976) etc]. On the other hand few theoretical attempt has been done for technological aid to the developing countries except informal observations [Desa (1978), Rao (1978), etc.]. Furthermore the evaluation of technological aid has not been tackled so far. This paper challenges this problem by proposing a method which does not necessarily require the availability of well-organized timeseries data.

This method is based on a set of differential equations whose special form was proposed for biocybernetical systems. It is known that the applicability of the differential equation approach to social systems is quite limited because this approach generally requires the high availability of well-organized data and excludes the multiplicity of variables. But this paper attempts to overcome this drawback of the conventional differential equation approach. The first approximation in expressing the behaviour of a developing country actually does not require many variables if the policy of the country is clearly defined (this holds with many developing countries) and if the purpose of the analysis is confined to the evaluation of this policy. The data availability is not necessarily required at first, and conversely the highly developed theory of differential equations provides a tool to estimate the parameter values.

The proposed differential equation system is a generalized Lotka-Volterra equation which generates various forms of trajectories. The real behaviour can be expressed by a set of these trajectories, and the empirical verification will be presented below.

2. MODEL STRUCTURE

The industrialized country is, as its name, primarily interested in the growth of industry, especially the heavy industry. The consumption and the technology stock in the industrialized country depends on its heavy industry. The newly industrialized country is, on the other hand, primarily interested in developing of industry, especially the light industry by exploitting the natural resources as its materials. The consumption and technology stock in the developing country depends on its light industry. Even its natural resources production depends indirectly on its light industry in that the facilities for the natural resources production is imported through exchange with the products of the light industry. Hence the newly industrialized country may well be represented by its light industry. Hence the two-variables model may be valid in expressing the relationship between the developed and developing countries. Contrast between the developed and developing countries is so significant that the detailed difference among the developed countries may be negligible. On the other hand the developing countries may be classified into very different categories because their industries are quite dependent on their natural conditions. Hence there is no universal transaction type over the all categories of the developing countries. Rather, a developing country communicates mainly with other developing countries of the same categories, forming a homogeneous closed group of the developing countries. Such situations allow to reduce the relationship between the developed and developing countries to a bilateral relationship between M(materials producing country) and I(industrialized country).

Figure 1 illustrates this relationship. The nodes in Fig. 1 denote the following things.

N: the nature or natural source (e.g., land, mine, oil field etc.)

P: the simple process of the primal resources. (e.g., spinning mills, refineries etc.)

L: the industry in M, especially the light industry.

T_M: the technological resources (skilled workers, training centers, engineers etc.) in M.

C_M: the consumption in M.

H: the industry in I, especially the heavy industry.

T_I: the technological resources (R & D man-power, laboratories, engineers etc.) in I.

C_I: the consumption in I.

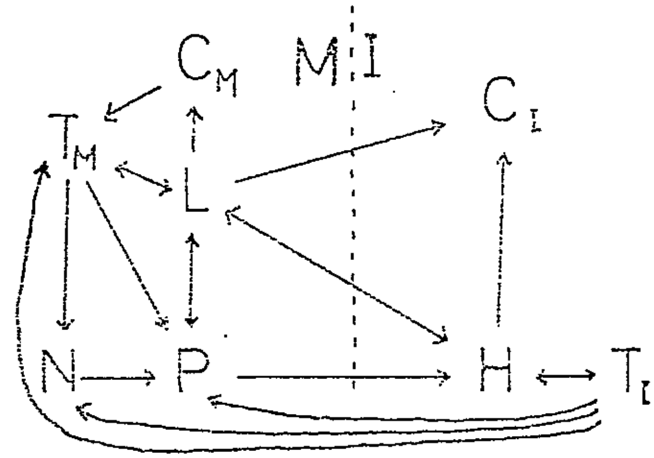

Fig. 1. Relation between materials-producing and industrialized countries

The arrows in Fig. 1 denote following flows.

$N \rightarrow P$: the flow of the natural materials.

$P \rightarrow L$ and $P \rightarrow H$: supply of the materials for industries.

$L \rightarrow C_M$, $L \rightarrow C_I$ and $H \rightarrow C_I$: supply of consumer goods.

$L \rightarrow H$: supply of intermediate goods.

$H \rightarrow L$: supply of plants.

$L \rightarrow T_M$ and $H \rightarrow T_I$: the investment for technological development.

$L \rightarrow P$: supply of tools.

$T_M \rightarrow L$, $T_M \rightarrow N$, $T_M \rightarrow P$ and $T_I \rightarrow H$: application of developed technology.

$T_I \rightarrow T_M$ and $T_I \rightarrow N$: technological aid.

$C_M \rightarrow T_M$: the expenditure for education from household.

Some unsymmetricity exists between M and I. That is, the following arrows do not exist in Fig. 1 because of the reasons stated below.

$H \rightarrow C_M$: the market of the developing country is protected.

$T_M \rightarrow T_I$: the technological resources of the developing country is not transferred to the industrialized country.

$C_I \to T_I$: the education expenditure no longer depends on I because of its saturation, remaining constant.

The absence of these arrows is inessential to our model in the following section and our formal discussion based on this model. In fact the brain drain $T_M \to T_I$ may be taken into consideration. For the preciseness in measurement these are desired to represent the material (energy or resource) flows.

3. CHARACTERIZATION OF FEEDBACK LOOPS

The diagram of Fig. 1 contains many feedback loops. They are classified into the "single," "double," "multiplicatively interconnected" and "disturbingly interconnected" loops.

The single loop or the straight loop;

$L \leftrightarrow T_M$ and $H \leftrightarrow T_I$: the development of industries stimulates almost straightly the technological development which reciprocally advances almost straightly the industrial development. (The time-lag is neglected here.)

$L \leftrightarrow P$: supply of tools improves almost straightly the process in efficiency and quality of products. Reciprocally this advances almost straightly the industrial development.

The double loop or the loop in respect to L or H with the effect duplicated by another single loop in respect to L or H respectively:

$L \to T_M \to P \to L$: the effect of application of T_M to P is amplified or materialized by another single loop $L \leftrightarrow P$ of supply of tools.

$L \to C_M \to T_M \to L$: the effect of education is amplified or is materialized by another single loop $L \leftrightarrow T_M$ of the technological investment.

The multiplicatively interconnected loop or the loops with the joing effect between L and H:

$L \rightarrow T_M \rightarrow N \rightarrow P \rightarrow L$ with $H \rightarrow T_I \rightarrow N \rightarrow P \rightarrow L$: the application of T_M works jointly with the application of T_I. That is, a combined effect of indogeneous self-development and exogeneous assistance from abroad.

$H \rightarrow T_I \rightarrow T_M \rightarrow L$ with $L \leftrightarrow T_M$: the aid from T_I works jointly with the investment from T_M.

$H \leftrightarrow L$: Though it is often merely a set of independent oneway arrows, the both industries sometimes profit each other by exchanging intermediate goods with the plants. However, the opposite situation could occur that the import of plants from H arrests the level of L and that the level-up of L threats H. In such a case the loop is the disturbingly interconnected loop to be discussed soon.

The disturbingly interconnected loops or the loops with the effect hindered by the other;

$H \rightarrow T_I \rightarrow T_M \rightarrow L \rightarrow H$: the technological aid $T_I \rightarrow T_M$ advances T_M and then L. Thus, owing to this aid, H may threat itself by way of L resulting in the negative effect proportional to H/L. Since $1 < H/L < \infty$, this means that the negative effect gets more serious as L increases. If the growth of H is saturated, H can be treated as a constant and now the effect is inversely proportional to L.

Some loops contained in the diagram of Fig. 1 are omitted from the above list because of their negligibility. For example, the loop $L \rightarrow C_M \rightarrow T_M \rightarrow N \rightarrow P \rightarrow L$ is omitted because $C_M \rightarrow T_M$ is not a strong flow and such a long-chained loop may be weak as the product of the small amounts of flows.

A set of connected arrows, though not a loop, works cooperatively or competitively each other.

The set of competitively interconnected arrows;

$L \rightarrow C_I$ and $H \rightarrow C_I$: the both industries supply the consumer goods competitively. The competitivity may be proportional to L/H, or more precisely T_M/T_I which, however, may again be proportional to L/H

4. THE GROWTH EQUATIONS

Now the growth of L and H is expressed as in (1) and (2).

$$dL/dt = (a + bL + cL^2 + dLH + eH + fL/H + g/H)L \qquad (1)$$

$$dH/dt = (h + iH + jH^2 + kHL + lL + mH/L + n/L)H \qquad (2)$$

where the parameters denote the causes of growth in association with the diagram of Fig. 1 as follows.

a: the intrinsic potential power for the natural growth by the already accumulated and existing resources (e.g., the existing levels of education and managerial skillfulness, the existing degree of the social stability etc.). Normally $a > 0$ but it is possible that $a \geqq 0$. Hence a >, =, < 0.

b: the acceleration rate by the "single" feedback loops $L \leftrightarrow T_M$ and $L \leftrightarrow P$. If the overinvestment is done for T_M or P, then it may hinder the growth of L, yielding $b < 0$. Hence b >, =, < 0.

c: the acceleration rate by the "double" feedback loop $L \rightarrow C_M \rightarrow T_M \rightarrow L$. If the overconsumption is made or the wage is not used enough for education, it is possible that $c \leqq 0$. Hence c >, =, < 0.

d: the acceleration rate by the "multiplicatively interconnected" feedback loops $L \to T_M \to N \to P$ interconnected with $H \to T_M \to N \to P \to L$ and $L \leftrightarrow T_M$ interconnected with $H \to T_I \to T_M \to L$. If their effects are independent each other, d is split into d_1 and d_2 and the parameters are reset as $b \to b + d_1$, $e \to e + d_2$ and $d \to 0$. Hence $d = 0$ but actually $d >, =, < 0$ for the reason to be discussed about e.

e: the acceleration rate by an arrow which is dependent exclusively on H. That is the arrow $H \to L$. As the import of plants from the industrialized country might hinder the advance of the developing country, it is possible that $e \leq 0$. On the other hand, if $H \to L$ is dependent on $L \to H$, then $d \to d + e$ and $e < 0$. Hence $e >, =, < 0$. $e > 0$ signifies the assisting or positive effect of the developed country on the developing country and $e < 0$ signifies the hindering or negative effect.

f: the acceleration rate by the "disturbingly interconnected" loop $L \leftrightarrow H$ can be a loop of this kind. Despite this disturbance the effect may still remain positive with its magnitude diminished by the level of H. The set of "competitively interconnected" arrows $L \to C_I$ and $H \to C_I$ is also relevant to this term. If H declines for some reason, the decline of supply from H may hinder L, yielding $f \leqq 0$. Hence $f >, =, < 0$.

g: the acceleration rate by the "disturbingly interconnected" loop or by the set of "competitively interconnected" arrows with L approximated as constant. This approximation is valid when the growth of L is slow. As was discussed about f, $g >, =, < 0$.

When the parameters are interpreted as above, all the parameters may take any sign;

$$a, b, c, d, e, f, g >, =, < 0$$

The similar argument makes clear which parameter in (2) denotes which loops or set of aroows and again yields

$$h, i, j, k, l, m, n >, =, < 0$$

Its detail is as follows.

h: the intrinsic potential power for the natural growth by the already accumulated and existing resources. It can be negative and hence $h >, =, < 0$.

i: the acceleration rate by the "single" feedback loop $H \leftrightarrow T_I$. If overinvestment is done for R & D, its effect may be negative. Hence $i >, =, < 0$.

j: the acceleration rate by the "double" feedback loop. In the diagram of Fig. 1 no double feedback loop exists with respect to H. But a possible double feedback loop may be $H \rightarrow C_I \rightarrow T_M \rightarrow H$ like one with respect to L. Similar to b in (1), $j >, =, < 0$.

k: the acceleration rate by the "multiplicatively interconnected" feedback loop $H \rightarrow T_I \rightarrow N \rightarrow P \rightarrow H$ interconnected with $L \rightarrow T_M \rightarrow N \rightarrow P$. If their effects are independent each other, k is split into k_1 and k_2 and the parameters are reset as $i \rightarrow i + k_1$, $l = l + k_2$ and $k \rightarrow 0$. The loop $H \rightarrow T_I \rightarrow T_M \rightarrow P \rightarrow H$ interconnected with $L \rightarrow P$ falls also in this kind of loop. If their effects are again independent each other, the parameters are reset in a similar way. Hence $k \geqq 0$ but possively $k = 0$ for the reason to be discussed about l.

l: the acceleration rate by an arrow which is dependent exclusively on L. That is the arrow $L \rightarrow H$. As the growth of L may help H by providing the intermediate goods of high quality or may threat H by competition, l can be positive or negative. If $L \rightarrow H$ depends on the supply of plants from H, that is, if $L \to H$ depends on $H \to L$, then $k \to k + 1$ and $l \to 0$. In another situation $L \leftrightarrow H$ falls into the category of the disturbingly interconnected loop and the parameters are reset as $m \to m + 1$ and $l \to 0$. Hence $l >, =, < 0$. $l > 0$ signifies the contributing or positive effect of the developing country on the developed country and $l < 0$ signifies the destructive or negative effect.

m: the acceleration rate by the "disturbingly interconnected" loop $H \to T_I \to T_M \to L \to H$ through which H may be disturbed by L. Also the loop $H \leftrightarrow L$ may fall in this category. The disturbance may make the effect negative or may not be enough to do so, keeping it still positive. The set of "competitively interconnected" arrows $H \to C_I$ and $L \to C_I$ may fall herein with either sign. Hence $m >, =, < 0$.

n: the acceleration rate by the "disturbingly interconnected" loops or by the set of "competitively interconnected" arrows with the growth of H considered as constant. This is valid when H is saturated or the effect of H no longer depends on its level. As was discussed about m, $n >, =, < 0$.

If $e > 0$ and $l > 0$, then the relation between the both will be called mutually assisting. If $e < 0$ and $l < 0$, then mutually conflicting.

5. STABILITY AND SENSITIVITY ANALYSIS

The historically wellknown models by Lotka-Volterra, Gause and Leslie-Gower are the special cases of the system of simultaneous equations (1) and (2).

(i) $a, l > 0$, $e, h < 0$, $b = c = d = f = g = i = j = k = m = n = 0$ yields the Lotka-Volterra model. This normally gives a family of elliptical trajectories around the equilibrium, yielding the oscillatory stability or the conventional gap of business cycle.

(ii) $a, h > 0$, $b, e, i, l < 0$, $c = d = f = g = j = k = m = n = 0$ yields the Gause model. This gives various trajectories, yielding the stable or unstable equilibria possibly with the vanishing of either side depending on the quantitative relationship between the non-zero parameters. Note that this represents the mutually conflicting relation.

(iii) $a, h > 0$, $e, m < 0$, $b = c = d = f = g = i = j = k = l = n = 0$ yields the Leslie-Gower model. This gives the closing spiral trajectory converging to the stable equilibrium.

In the general case the trajectory, its oscillation and convergence, the equilibria and their stability can be analyzed without solving the differential equations (1) and (2) by the following computational procedure.

step 1. Determine the present locations (the initial conditions) of L and H. Let it be (L_0, H_0).

step 2. Calculate dL/dt and dH/dt at $L = L_0$ and $H = H_0$ respectively.

step 3. Locate (L_t, H_t) by using (L_0, H_0) and the values of the derivatives at this point. Repeat this process for $t = 1, 2, \cdots$.

step 4. For the sensitivity analysis, take another initial condition and follow the same process.

If only the conceptual scheme is needed, the following manual procedure may be sufficient.

step 1'. Determine where dL/dt and dH/dt are positive, zero and negative respectively by solving the equations $dL/dt = 0$ and $dH/dt = 0$ separately according to (1) and (2) respectively. This information determines where each of L and H increases, remains constant or decreases respectively.

step 2'. Draw a contour of the derivatives values of each of L and H.

step 3'. Determine the present location of L and H.

step 4'. Draw the trajectory starting with the present location and moving in the direction of the derivatives values. Continue it.

step 5'. For the sensitivity analysis, take another starting point and follow the same procedure.

The procedure of step 1' divides the whole space into the several sections in each of which a trajectory behaves very differently. If the present state is located in a wrong section by observation error, the whole conclusion may be completely misleading. To avoid this, the sensitivity analysis or the robustness analysis of step 4 or step 5' is absolutely needed.

Another kind of sensitivity analysis is also important from a policy-analytical point of view. This is done by varying the parameters. The values of the parameters depend on the policy and the social state. As the social state itself could be changed by the proper policy, the values of the parameters could be said dependent on the policy.

Varying the parameters means shifting from one trajectory to another trajectory. This means, in a certain situation, shifting from an asymptotic trajectory toward a stable equilibrium to another asymptotic trajectory toward a stable equilibrium, shifting from an oscillatory trajectory to an asymptotic trajectory toward a stable equilibrium or shifting from an oscillatory trajectory with a certain cycle to another oscillatory trajectory with another cycle.

6. PROCEDURE FOR POLICY EVALUATION

Always the serious problem of mathematical models is their applicability. Especially the problems how to quantify the parameters and to locate the present state in a quantitative way are quite difficult. However, our model proposed above can be free from this difficulty with the aid of the two kinds of sensitivity analysis. When the data is unavailable, the following procedure may be useful.

step 1. Identify the past trajectory by using the data on the past behavior. This possibly contains some catastrophic shifts of trajectories.

step 2. Express this trajectory as a collection of several segmented trajectory curves.

step 3. Identify the values of the parameters of these segmented trajectory curves.

step 4. Examine the validity of these parameter values.

Here the validity means the fitness with the past data or, if statistical data are unavailable, the interpretability of the parameter values and their changes.

step 5. If the result of this examination reveals these parameter values are invalid, this indicates the model itself is invalid. If it reveals they are valid, then go to step 6.

step 6. Extend the last segment curve for the future forecasting. If the forecasted trajectory is satisfactory, go to step 7. If unsatisfactory, go to step 8.

step 7. Examine whether the present values of the parameters are expected to remain stable or not. If so expected, the future is expected satisfactory and the strategy is to prevent their changes. If not, go to step 8.

step 8. Seek the strategy to vary the parameter values toward the desirable ones by some control.

For the last but the most important remark on the policy evaluation, it must be noted that the most controllable factor in the diagram of Fig. 1 is the technological aid T_I in that it alone is under the direct administration of the government. Hence the level of T_I is the direct result of policy.

7. MATERIALS PRODUCTION DEPENDING COUNTRY

In the foregoing section the light industry L represents the materials producing country M. This reflects the strategy of the newly industrialized country (or the middle income country) which promotes industrialization. However, many materials producing countries remain dependent on the materials production and are still interested primarily in the materials production increase. In such a situation the strategy is to raise the level of P instead of L. Thus the analysis must be devoted to the expression (3) instead of (1).

$$dP/dt = (o + pP + qP^2 + rPH + sH + tP/H + u/H)P \quad (3)$$

where the parameters denote the causes of production increase in association with the diagram of Fig. 1 as follows.

o: the intrinsic potential power for the natural growth by the already accumulated and existing resources. When mines are young, $o > 0$ but when mines are old, $o \leqq 0$. Hence $o >, =, < 0$.

p: the acceleration rate by the "single" feedback loop $P \leftrightarrow L$ and $P \leftrightarrow T_M$. Note that, when the wealth of country largely depends on P, the level of T also depends primarily on P. $p \gtrless, =, < 0$ according as the investment for L or T_M is properly done or not.

q: the acceleration rate by the "double" feedback loop $P \rightarrow T_M \rightarrow L \rightarrow P$ the effect of which is "doubled" by $P \rightarrow L$. $q >, =, < 0$ according as the investment for T_M and L is appropriate or not.

r: the acceleration rate by the "multiplicatively interconnected" loop $P \rightarrow H \rightarrow L \rightarrow P$ in which P and H cowork. Normally $r \geqq 0$ but possibly $r < 0$ for the reason to be given in discussing about s.

s: the acceleration rate by the feedback loops $P \rightarrow H \rightarrow T_I \rightarrow T_M \rightarrow P$, $P \rightarrow H \rightarrow T_I \rightarrow N \rightarrow P$ and $P \rightarrow H \rightarrow T_I \rightarrow T_M \rightarrow N \rightarrow P$. Actually their effect depends very little on P because, if the industrialized country I is developed highly enough, T_I depends only on the culture in I. Normally $s \geqq 0$ but possibly $s \leqq 0$ because T_I may be inappropriate to the materials production country M. If their effect depends on P, they contribute to this term with parameter r. Then the parameters are reset as $r \rightarrow r + s$ and $s \rightarrow 0$. Hence $s >, =, < 0$.

t: the acceleration rate by the loops discussed about s if their effect is disturbed by H or, what is almost the same thing, by T_I while it is dependent on P. This disturbance may make t negative or t may remain positive despite this disturbance. Also possibly $t = 0$ for the reasons given in discussing about u. Hence $t >, =, < 0$.

u: the acceleration rate by the loops discussed about t if their effect is disturbed by H and is almost independent of P. As was discussed about t, $u >, =, < 0$.

8. AGRICULTURE DEPENDING COUNTRY

The similar but slightly different argument holds with the agricultural production depending country. In this case the light industy L is excluded from country M and is not included in country I. The heavy industry H and the light industry L may be located in two distinct industrialized countries (a highly industrialized country and a newly industrialized one) but it is assumed here, for the simplification, that both are located in the same country I. This simplification does not damage our analysis because our analysis is concerned with the relationship between the representatives of the both sides of the developed and developing countries rather than the relationship among every country.

Now P is replaced with agriculture A, and L shifts to the right, resulting in Fig. 2. The resulting equation to replace the equation (1) is omitted to avoid the trivial extension of the foreging discussion.

9. EMPIRICAL VERIFICATION

Figure 3 illustrates a simplified or "ideal typus" behaviour of the developed and developing countries with a, e, g, l, n < 0, b, i > 0 and c, d, f, h, j, k, m $= 0$. Note here that $e < 0$ and $l < 0$. This signifies that the relation between the both sides is mutually conflicting. Many arrows are responsible for this due to their inappropriate level of flow or their inbalance. One of the clear reasons for this is that the arrow of technological aid is very weak.

The parameter signs which signify the basic structure remain unchanged for a relatively long period but the parameter values tend to change relatively often. In the decade of 1970's, the intensive technology innovation for energy conservation reflects in the drastic change of the parameters values in the late 1970's.

The "ideal typus" generates several types of trajectories as denoted by T_0 - T_4 in Fig. 3 where T_x' denotes the extension of trajectory T_x after the change of parameters values as the effect of the rapid technology innovation in the mid and late 1970's.

Trajectory T_0: conventional business cycle. T_1: in the early stage the both grow nearly proportionally to north-east; in the middle stage a crisis (oil crisis) makes the former sharply decline and the latter grow to north-west; in the third stage the former recovers much more quickly than the latter. T_1': the change of parameter values by innovation in energy technology or so shifts the conventional cycle pivot. T_2: basically same as but more amplified than T_1. T_2': the change of parameter values turns the trajectory back to north-west. T_3 : the same as T_2' without the change of parameter values. T_3': the change of parameter values turns the trajectory again to north-west. T_4: the developed country just continues declining while the developing country just grows. T_4': the change of parameter values turns the trajectory back to T_3 or T_2 or even T_1. T_4 may be desirable to a side of L but some control (e.g., innovation in energy technology) may hinder it.

As the economy generally grows almost monotonically in time, it may be desired to normalize or deflate the economic statistics by dividing it by a proper variate or by subtracting a proper variate from it. Otherwise the first approximation would be merely the monotone growth, and the second term for the variation around the growth trend would sometimes be negligible as compared to the first term of the growth trend. For this reason the variates are normalized and hence the ratio appear in Fig. 4 - 7.

While Fig. 3 illustrates an "ideal typus," Fig. 4 provides its real example in the growth rate of industrial production. The three countries, Malaysia, Canada and Australia which supply materials except oil to Japan follow trajectory T_1 or T_1'. Even the two high technology countries (Canada and Austria) follow T_1, indicating that our model holds with the material producing countries whether developed or developing. Saudi Arabia which is a top oil supplier to Japan follows T_4' in terms of the export surplus ratio (= $(exp_t - imp_t)/(exp_t + imp_t)$) in Fig. 5 presumably due to lack of high technology. Fig. 6 is obtained from Fig. 4 by replacing Japan and the Japan-related countries with U.K. and the U.K.-related countries respectively, resulting in T_1. Fig. 7 is its French version, resulting in T_4. Fig. 4 - 7 altogether prove that the family of trajectories generated by the single set of equations depicted in Fig. 3 has somewhat general power of explanation.

The parameters a - n can take any signs and any numeric values in (1) and (2). Substituting arbitrary signs and values there generates other "ideal typus" different from the one in Fig. 3. Every possible "ideal typus" can be tried in this way. However, in the effort made so far, the one in Fig. 3 generates the most reasonable trajectories which fit the real data.

10. CONCLUSION

A mathematical model is proposed to evaluate the technological aid to the developing countries. The merit of this model is not necessarily to require the high availability of data. The proposed procedure proves quite useful to identify the real behaviour of the developing countries. The oscillatory behaviour of the developing countries is shown represented well by this model.

The model presented herein claims that the conflicting relation is the basic structure between the developed and developing countries. Despite this basic structure, however, it also explains both the seemingly mutual assistant relation inbetween in the early 1970's and the seemingly cyclic relation inbetween in recurring to the point of the early 1970's at the end of 1970's.

Many factors may be responsible for this conflicting relation. Clearly one of the reasons for this is that the technological aid is so weak that the accumulated stock in the heavy industrial sector in the developed country does not flow back to the developing country. Even conversely, the high stock in the developed country gives rise to rapid technology innovation in the developed country, resulting in a more favourable situation to the developed country.

This model is adequate to represent the energy or resource flows but, due to the unavailability of such material flow data, this model can at present be verified only in economic terms. However, it derserves noting that a series of the recent energy analyses (Kawakami, 1981; etc) revealed that the energy value of a commodity is nearly proportional to its price. This discovery implies that the analysis in economic terms approximates the analysis in energy terms. This justifies our verification above. Some explanation may be needed about the energy value; Every commodity is measured how much energy it can produce or save or it consumes in its reproduction. In this way it is measured in energy terms as it was once measured in gold.

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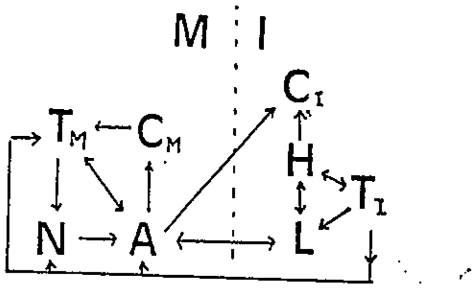

Fig. 2. Relation between agricultural and industrialized countries

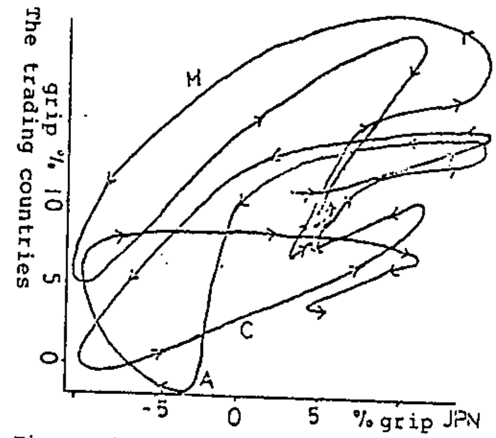

Fig. 4. Japan vs the trading countries, '71-78

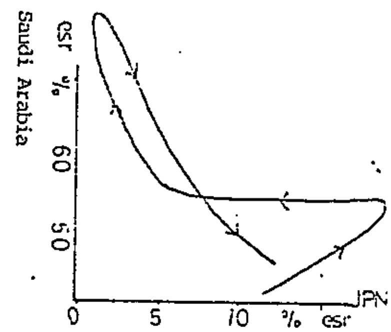

Fig. 5. Japan vs Saudi Arabia, '70-77

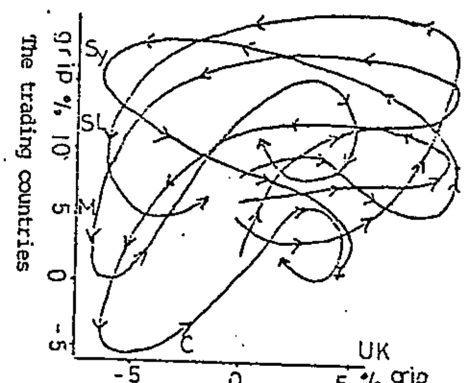

Fig. 6. UK vs Malaysia, Sri Lanka, Syria, Australia & Canada, '71-78

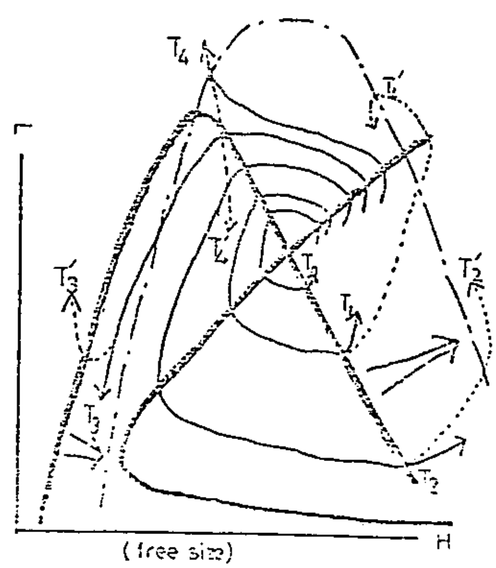

Fig. 3. Family of trajectories generated by the equations (1) & (2)

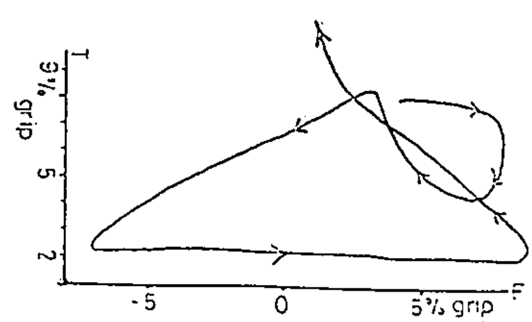

Fig. 7. France vs Tunisia, '71-78

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