A DEVELOPMENT STRATEGY WITH FOREIGN BORROWING:

A neo-austrian approach

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Introduction

The debt of developing countries is one of the most acute problems of the world economy. Both its magnitude and maturity structure have been deemed to pose a serious threat to the stability of the international monetary system. Coping and often rescheduling a mounting debt have become a primary concern of international institutions and private banks alike. Near default of various countries has practically discontinued net additional lending while banks have grown increasingly weary of rescheduling existing loans. Plans to come to the financial rescue and provide relief to heavily indebted countries have also failed to provide a lasting solution. Financial support to development has in consequence been if not entirely stopped at least seriously slowed down. Yet the need for it remains as great as ever. If industrialization is to continue in those countries that have already undertaken to pursue it and to begin as systematic and not hephazard means of structural change where it is yet to materialize, borrowing to sustain higher growth is crucial.

Borrowing, and over time debt, is here taken as an instrument to obtain badly needed physical capital; means of production the availability of which in the developed world shortens the route towards the goal of industrialization, i.e. a higher per capita consumption afforded by increased productivity. If a still undeveloped economy were to undertake to industrialize in total isolation it would have to set up processes of production from the very beginning in a context lacking complementarities and externalities on which much of the productivity levels depend. This has a twofold dimension. Firstly, since production takes time, the path to be trodden before consumption actually appears has to unfold through all the phases of the capital making stage. Secondly, even assuming knowledge of more or less advanced techniques, they cannot be activated as efficiently as in a more developed economic environment. It is in this sense that borrowing to import capital goods can be very helpful. It can clearly bridge the distance between capital making and actual production of final goods, but it can also provide, through the implied transfer, more efficient technologies. This is of paramount importance for it can set off processes of learning which will in turn be a source of further productivity growth.

This is, of course, generally recognized. Borrowing, however, sets a burden on the economy which can be met only by generating a flow of exports to match debt service. If the starting point of industrialization is an undeveloped economy with a very low income per head, insuring mere substistence, such a flow of exports can only come from the fruits of industrialization itself. This can occur on condition that external markets grow at least as fast as the pace of domestic development. But even if this event were to be taken for granted, and this is indeed a severe asbtraction from the realities of most LDCs, there is a deeper and more binding difficulty. The latter arises from the likely inconsistency between the debt own temporal profile, as defined by maturity and interest rates, and production profiles, as defined by technology and duration, for any given level of consumption per head. This difficulty is compounded by the fact that if structural transformation is to be achieved such production profiles must change accordingly.

In order to highlight the production effort required by accumulation and to assess the benefits as well as the burden implied by a policy of deliberate borrowing to quicken the pace of development, an appropriate analytical tool must be adopted. The emphasis that the neo-austrian approach puts on the temporal sequence of input and output flows, and the implied ranking of goods according to the distance separating them from final consumption, provides an appropriate framework. In this context development can be viewed as a sequential activity progressively leading to the production of equipment and then to that of final consumption goods.

Debt, however, may create dependence and threaten, if excessively burdensome, the very growth potential it is meant to strengthen (Bhaduri 1986). This raises the problem of repayment and eventual elimination of the outstanding stock of debt, even if consistency with financial conditions were to be verified, without foregoing either an already low consumption per head or growth. The answer to this key development issue lies with linking debt service to productivity increases engendered by a programme of domestic industrialization.

The aim of this paper is to address these problems by discussing the case of a country which borrows in order to accelerate its development process by importing capital goods and the technology embodied therein. In the analysis which is to follow we adopt the method pioneered by Hicks (1973) and further developed by Belloc (1980), Zamagni (1984), Violi (1984).

The paper is organized as follows. Section I draws the main stylized facts of a hypothetical developing country at the beginning of its development process and sets out the basic model in a closed economy context. Section II investigates the benefits of borrowing to import capital goods and the consistency between the growth target, consumption per head and the debt financial terms. Section III explores the main features of an import substitution strategy aimed at easing the debt burden and at raising productivity. In the context of the paper this implies setting up a domestic capital goods industry and transition from one state of equilibrium to another: in the language of the neo-austrian approach, it is a problem of traverse. Section IV, finally, links debt repayment to productivity growth. The latter is determined by learning processes which lower labour inputs in each phase of the production process.

I. The Economy and the Model

The economy we wish to discusss is highly stylized. It is yet to industrialize but as an act of deliberate policy it undertakes to do so. It is a surplus labour (Lewis 1954), backward agricultural economy. Social produce is not distributed according to market determined prices but shared out in accordance to agreed, mainly family oriented, social rules (Sen 1975a). Per capita earnings equal output per head and are near the subsistence level. At the beginning, the economy is assumed as closed; since population absorbs the entire net product, which is barely sufficent for subsistance, there is no scope for trading and there are no savings.

As it is the case in most surplus labour models, industrialization is feasible only by transferring part of the labour force, that which is not strictly needed to produce output, from agriculture to an infant industrial sector and by freeing its former compensation to supply real wages. Labour is thus assumed in perfectly elastic supply. As soon as industrial processes begin, they produce a bundle of final goods to provide the country with badly needed items of social consumption. For semplicity sake such a bundle can be understood as a vector of goods in strictly fixed proportions; thus, activity levels can be dealt with by means of a scalar. Wage rates are assumed as constant throughout while industry-agriculture terms of trade are also taken as fixed. This is a rather strong assumption. In most models terms of trade adjust to changing productivity levels in the two sectors. The reason why such an interesting problem is set aside is to concentrate on the compatibility between industrial processes and financial constraints to be analyzed in following sections. This is, therefore, a fix-wage, fix-price model.

The problem a country such as the one which is being portrayed faces is typical. Labour, in so far as it can be moved away from agriculture, is the only available resource. To set off an industrial process, equipment has to be manufactured before final goods can. Producing this equipment requires more equipment, defining a phase which lies one step backward from final output. Successive phases can, in principle, be identified producing capital goods at various removes from the end of the capital construction stage. In each phase, the result of the previous one and labour concur to produce equipment which lies on step nearer final output. In this way, the production process is taken over time as a whole even if separable in successive phases (Georgescu-Roegen 1971, Cantalupi 1986). This method of viewing industrial activity is what Hicks (1973) calls a vertically integrated, neo-austrian profile. By employing it in the analysis which is to follow we shall be provided with useful insights as to the technical requirements, phase by phase, and roundaboutness of the production process. As usual, steady state conditions can be derived but, what is more, the approach in question allows a sequential analysis of change of states: we shall, in other words, undertake to describe a traverse.

Although closed, the economy has information on how to operate industrial processes. Indeed, it has full engineering knowledge of the same set of techniques as advanced economies. Techniques however, cannot be run as efficiently: the country still lacks vital skills and it cannot avail itself of complementarities and externalities whose benefits can only be reaped in a developed context. A chosen technique can be operated from the very beginning by employing labour only.

his is the typical assumption of the integrated neo-austrian model. Although at each successive phase previous output enters production, the technique which the country adopts can be described by a flow of inputs, one of outputs and an optimal duration. The latter is the result of free truncation (Nuti 1973, Sen 1975b, Hageman-Kurz 1976, Ross-Spatt-Dybvig 1980).

Let a(u) and b(u) be the labour input and the final output respectively, such that

$$a(u) \geq 0 \ , \ u \ [0,n]$$

$$b(u) = \begin{cases} 0, u \quad [0,k_o] \\ \geq 0, u \quad [k_o,n] \end{cases}$$

k_o marks the end of the capital making period after which utilization begins, lasting until n when the process ends and equipment is scrapped with no residual value. The construction period $[0,k_o]$ can, in turn, be viewed as a sequence of phases (k_j,k_{j-1}) which conventionally mark a stage of completion $j=0,1,2...\vartheta$, $k_\vartheta=0$. Continuity is assumed throughout.

Technical choice is either a matter of convenience or of deliberate policy. If the rate of return is the criterion, a trade-off between the latter and the wage rate is established

$$1) \quad w = \frac{\int_o^n b(u)\, e^{-ru}\, du}{\int_o^n a(u)\, e^{-ru}\, du}$$

for each of the known techniques; r is the rate of return. The set of all techniques defines a locus from which the one maximizing r is selected. This need not be the only criterion. Instead, a planning body might prefer to adopt the technique which yields the highest growth rate for a given per capita consumption (Sen 1968). In the analysis which is to follow it is assumed that this is, indeed, the case. Consumption per head covers the given wage rate plus social consumption which is expressed in terms of the final good. Their sum can conventionally be indicated by $\tilde{w}$. In this case, a consumption per head, growth rate trade-off is defined by

$$2) \quad \tilde{w} = \frac{\int_o^n b(u)\, e^{-gu}\, du}{\int_o^n a(u)\, e^{-gu}\, du}$$

where g is the growth rate. Note that n in 2) need not be the same as in 1) on account of different truncation. Indeed, the technique chosen on the basis of the highest g is generally different from the one which would have been chosen had the criterion been the rate of return (Fig. 1).

At any time t, output, employment and total consumption are respectively given by:

3) $$B(t) = \int_{o}^{n} b(u)\ x(t-u)\ du$$

4) $$A(t) = \int_{o}^{n} a(u)\ x(t-u)\ du$$

5) $$C(t) = \tilde{w}\ A(t)$$

while equilibrium is expressed by the following equation:

6) $$\int_{o}^{n} q(u)\ x(t-u)\ du = 0$$

where $q(u) = b(u) - \tilde{w}\ a(u)$; $x(t)$ is the number of starts of new processes. In steady state, when $x(t) = x(0)e^{gt}$, 6) is the equivalent of 2).

II. Industrialization in an open economy: importing capital goods

The foregoing section sets out the basic relations of a steady state industrialization path carried in full isolation.

An alternative is, however, at hand from the very beginning. The country may import capital goods. In the language of the neo-austrian approach this means purchasing the results of the entire capital making period or of some of its segments (k_j, k_{j-1}). The advantage is twofold. Firstly, the time required to begin production of final goods is shortened; secondly a transfer of more efficient technology occurs. This is very important. For want of basic skills and of an integrated production system, the economy cannot attain, for any chosen technique, the best practice which normally prevails in a fully developed context. Thus, importing capital goods increases technical efficiency and sets off a process of learning-by-using (Rosenberg 1982). We assume, in this section, that the country in question chooses to import the entire $(0,k_o)$ segment in order to start producing final goods at once.

An account of increased efficiency, the potentially attainable growth rate, given $\tilde{w}$, is higher. It is not, however, as high as the one achievable in a developed country for the utilization period $[k_o,n]$ in still not as efficient. Although the country stands to gain from such a transfer of technology, the latter need not be appropriate to the ruling $\tilde{w}$ rate. Imported capital goods, the $[0,k_o]$ segment, are manufactured according to a technique which is most profitable given the wage rate, $\hat{w}$, ruling in the exporting developed country. It may conveniently be assumed that the choice of technique criterion in such a country is the maximum rate of return. On account of the economic smallness in respect to the latter, the developing country is a price-taker. Had it been in a position to choose freely and autonomously the technique, it would have chosen the one appropriate to $\tilde{w}$ so as to maximize the growth rate. In this sense, technology is not appropriate; it is, however, beneficial.

Assuming equilibrium in the developed country, the price of imported capital goods is:

$$7) \quad P_o = \int_0^{n_a - k_o} q_a\,(k_o+u)\, e^{-\hat{r}u}\, du$$

where $q_a(\cdot) = b(\cdot) - \hat{w}\, a(\cdot)$ and subscript a refers to the technique chosen in that context, $\hat{r}$ is the maximun rate of return obtainable through a technique truncated at n_a.

In the situation mentioned above, our developing country cannot generate exports in exchange of capital goods. It will be able to purchase them only by obtaining a loan for the amount equal to their value, $P_o x(\cdot)$, where $x(\cdot)$ is the number of starts of a process which begins at k_o and ends at n.

We assume that borrowing takes place in the exporting country and that the importing one cannot influence, on account of its economic size, ruling financial terms. The latter can appropriately be described by a rate of interest, i, and a maturity period m. Repayment is to take place through instalments inclusive of both capital and interest. For the time being, they are assumed to be constant and equal to:

$$z_o = P_o \left\{ \int_o^m e^{-iu} du \right\}^{-1} \tag{8}$$

In the case of best practice operators, i.e. of processes started in a developed context, if repayment is to take place at all, $i \leq \hat{r}$ and $m \leq n_a - k_o$. Equilibrium requires, however, that $i = \hat{r}$, otherwise no production of capital goods would take place since the actual rate of return, r^*, to be obtained from borrowing and purchasing capital goods at price P_o, would exceed $\hat{r}$ which is the maximum rate yielded by operating the entire process. Furthermore, since repayment must not only take place but it must do so within the required span of time m the latter must equal $m = n_a - k_o$ if $i = \hat{r}$. For this same reason m cannot outlast $n_a - k_o$ (1). In a developing context, the technique is less efficient but consumption per head is lower, possibly much lower. If default is not to occur, the flow of net proceeds $q(\cdot)$ discounted at k_o when the process actually begins must insure repayment of P_o:

$$P_o = \int_o^m q(k_o+u)\, e^{-iu} du \tag{9}$$

for $i = \hat{r}$. 9) is a financial constraint set on the developing country process. Its significance can be best understood if it is expressed in the form of a consumption per head, rate of interest trade-off:

$$10) \quad \tilde{w} = \frac{\int_o^m b(k_o+u)\, e^{-iu}\, du - P_o}{\int_o^m a(k_o+u)\, e^{-iu}\, du} \quad ; \quad \frac{d\tilde{w}}{di} < o \, .$$

In 10) the rate of interest is a function of the distributive variable $\tilde{w}$. If i and m are imposed by the banking establishment, it is $\tilde{w}$ to adjust, which means that consumption per head must be made compatible with the debt burden. This might very well cause an unbearable situation in case $\tilde{w}$ were to be made lower than the subsistence wage. Since $q(\cdot)$ differs from $q_a(\cdot)$ on account of efficiency and wage rates, m may be allowed to differ from n_a-k_o, provided 9) is satisfied.

Equilibrium must now be recast to take debt into account. The latter can be serviced only by generating exports from output of final goods. Agriculture, in fact, provides only the subsistence wage fund. Thus, repayment is to be insured by the very outcome of the industrialization process. It will be assumed that a market for such export exists at constant terms of trade. This is, of course, a very naive assumption. The reason for it is the same as in the case of constant agriculture-industry terms of trade. A market outlet for the products of a newly established industry is not something to be taken for granted. Indeed, the experience of indebted LDCs shows that generating a sufficient flow of net exports to service debt is quite problematic. We wish however to highlight problems of consistency between financial constraints and the development of a modern sector in the best of circumstances. In this case, full performance as indicated by 6) must now be rewritten as:

$$11)\quad \int_{o}^{n-k_o} q(k_o+u)\ x(t-u)\ du = z_o \int_{o}^{m} x(t-u)\ du$$

where the RHS indicates the cumulation of debt service and a matching flow of exports. In steady state equilibrium 11) becomes

$$12)\quad \tilde{w} = \frac{\int_{o}^{n-k_o} b(k_o+u)\ e^{-g\ u}\ du - z_o \int_{o}^{m} e^{-g\ u}\ du}{\int_{o}^{n-k_o} a(k_o+u)\ e^{-g\ u}\ du}\ ;\ \frac{\partial \tilde{w}}{\partial g_o} < 0\ ;\ \frac{\partial g_o}{\partial z_o} < 0$$

where g_o is the sustainable growth rate given $\tilde{w}$, m and z_o.

12) and 10) combined establish a relationship between the rate of interest and the rate of growth. Its analytical expression is rather fastidious but for the purpose of the following discussion it can be simplified, taking 8) into account, as:

$$13)\quad f(i) = \Phi\ (g_o, i)\ .$$

If the developing country has no leverage on financial conditions, as it is normally the case, the rate of interest, given m, determines the growth rate. Its impact is twofold. Firstly, it acts on the amount of surplus which can be allocated to consumption per head if debt is to be properly serviced. Secondly, it acts on the growth rate by determining the surplus to be absorbed by new starts. Note that

$$\frac{dg_o}{di} = \left(\frac{df}{di} - \frac{\partial\Phi}{\partial i}\right) / \frac{\partial\Phi}{\partial g_o} \; ; \quad \text{where} \quad \frac{df}{di} < 0; \; \frac{\partial\Phi}{\partial i} < 0; \; \frac{\partial\Phi}{\partial g_o} < 0 \; ;$$

Its sign, however, is not unique. df/di captures the impact of i on $\tilde{w}$: a higher i lowers $\tilde{w}$ but a lower $\tilde{w}$ raises g_o, although i by itself depresses it. Thus if df/di is larger than $\partial\Phi/\partial i$, in absolute terms, an higher rate of interest implies a higher growth rate. The opposite occurs if it is $\partial\Phi/\partial i$ to be larger. Quite generally, the fact that living conditions can be lowered acts as a buffer between interest and growth rates allowing the relationship to be positive. This occurs for a range of the rate of interest; outside, the relationship becomes negative in spite of worsening standards of living.

The growth of the economy as described by 11) and 12) at a steady state rate, g_o, requires a flow of credit to sustain it which increases at an equal pace. Outstanding debt grows likewise. This situation is highly unlikely to occur in practice since it implies no credit rationing even in the face of a mounting debt. Solely on risk considerations, the rate of interest would normally have to increase. Again, actual experience would suggest rising difficulties to keep up the pace of indebtedness. The problem ridden process of international liquidity creation illustrates this point. To keep the discussion as simple as possible, we choose not to discuss this issue; we assume, however, that the country's authorities are well aware of this problem and wish to reduce and eventually to get rid of debt altogether.

Debt growth can be easily described as follows: after a lapse u of time past borrowing P_o, the residual debt per process is:

$$13)\quad P_o(u) = P_o\, e^{iu} - z_o \int_o^u e^{i\tau}\, d\tau$$

Thus, the total at time t is

$$D(t) = \int_o^m P(u)\; x(t-u)\; du$$

which given 13) and steady state growth at g_o equals:

$$13.1)\quad D(t) = C(P_o,i,g,m)\; x(t)$$

For given P_o,i,g and m debt is a multiple $C(\cdot)$ of new starts (2).

III. Lessening the burden

In this paper, we hold that the key to lessening the debt burden lies with productivity gains associated with the creation of a capital goods industry. It has been argued (Rosenberg 1960, Ricottilli 1984) and shown empirically by various authors that a capital goods industry is a strong factor of productivity growth since it is continuously pressed both by users' needs and producers' competition to improve its output. This occurs by localized search (David 1975, Atkinson and Stiglitz 1969) which normally takes the form of learning-by-using (Rosenberg 1982) and learning-by-doing (Arrow 1962).

In a neo-austrian framework, setting up such an industry implies beginning the production process at en earlier stage of completion. This means that the developing country in question must undertake to produce at least one segment of the capital making period $[0, k_{\vartheta-1}, \ldots, k_j \ldots k_1, k_o]$. There is no a-priori reason why it should take up one phase rather than another. It could, for instance, undertake to equip the economy with the most backward lying ones. Learning-by-using, however, actually provides know-how for the phase which immediately precedes the one being operated. We postulate, therefore, that the country decides to begin capital making by moving one phase backwards from k_o to k_1 and to import a capital segment whose value is P_1. The latter is obtained from 7) by setting the lower integration bound equal to k_1. Since $b_a(u) \geq 0$, $u \in [k_o, n_a]$ and $b_a(u) = 0$, $u \in [0, k_o]$ while

$a_a(u) \geq 0$, $u \in [0,n_a]$, $P_1 < P_o$; more generally $P_{j-1} < P_j$, for $j = 0,1,\ldots\vartheta$.

The strategy carries a twofold advantage. Firstly, the initial unit value of imports is lowered from P_o to P_1. This causes a once-for-all fall in loans required to start activity. Secondly, it determines learning-by-using and -doing since different machines will be put in use and some produced. Productivity growth, the outcome of such processes, is difficult to forecast whereas the former advantage is, in principle, perceived from the outset. It will be assumed, therefore, that the switch to a different production profile is actually acceptable if and only if the new attainable growth rate is at least as high, i.e. if $g_1 \geq g_o$ given that $z_1 < z_o$. Such a growth rate follows as a solution of 12) where in lieu of k_o and z_o, k_1 and z_1 are respectively substituted.

Two problems arise at this point. The new production profile $[k_1,n]$ may not be consistent with financial conditions. Equations 9) and 10) modified to take into account the new profile and the initial unit import value, P_1, state the point. If $\tilde{w}$ is kept constant, a compatible interest rate, for any given m, must be applied. How is i to change depends on labour costs and output over the period $[k_1,m]$ given a lower import requirement P_1. No general case can be made. If, however, labour costs, as it is quite likely, are higher in the first leg of the process, than the interest rate would have to fall. This issue is of considerable practical importance for it shows that programmes of structural change may be inconsistent with ruling financial conditions set by external markets; unless, of course, standards of living be again allowed to adjust.

The second problem concerns the transition of the economy from one steady state, at rate g_o, to another, at rate g_1. This problem is what Hicks (1973) calls a traverse. Indeed, even if a suitable interest rate were to be charged, the switch to a production process would not be painless. Assuming that the adoption of the new profile occurs at a conventional date, t = 0, equilibrium is satisfied if the following full performance equation is fulfilled:

$$14)\quad \int_{t-(n-k_o)}^{o} q(k_o+t-u)\ x_o(u)\ du - z_o \int_{t-m}^{o} x_o(u)\ du +$$

$$+ \int_{o}^{t} q(k_1+t-u)\ x_1(u)\ du - z_1 \int_{o}^{t} x_1(u)\ du = 0$$

where $x_o(\cdot)$ and $x_1(\cdot)$ denote the starts of the old and new processes respectively. 14.) indicates that after the new one has been started the economy is still operating the older; output and employment result as a combination of the two. Note that $t < n-k_o$ while m is assumed as $m < n-k_o$ to keep notations as simple as possible.

The profile of $x_1(t)$ is the unknown of the equation shown above. To assess its path during the traverse a comparison can be made with the one the economy would have followed had no change occurred. The latter, the reference path, is the steady state solution of 11.). By taking the difference between the two, the following equation holds:

$$15)\quad \int_{o}^{t} [q(k_o+t-u)-z_o]\ x_o(0)\ e^{g_o u}\ du = \int_{o}^{t} [q(k_1+t-u)-z_1]\ x_1(u)\ du$$

where the LHS is known. To solve it for $x_1(t)$, it is convenient to resort to a Laplace Transform (LT). In what follows we adopt a procedure introduced by Violi (1985). To render 15) more general for t (0,+∞) as required by the LT, and more manageable notationwise, rewrite it as:

$$15.1)\quad \int_{o}^{t} d_o(t-u)\ x(o)\ e^{gt}\ du = \int_{o}^{t} d_1(t-u)\ x_1(u)\ du$$

where $\quad d_i(t-u) = [q^+(k_i+ t-u) - z^+(k_i+t-u)]\ , \qquad i = 0,1$

and

$$q^+(k_i+t-u) = \begin{cases} q_o(k_i+t-u) & , \ u \in [t,t-(n-k_i)] \\ 0 & , \ u < t-(n-k_i) \end{cases}$$

$$z^+\ (k_i+t-u) = \begin{cases} z_i & , \ u \in [t,t-m] \\ 0 & , \ u < t-m \end{cases}$$

The solution, shown in the Appendix, is:

$$15.2)\quad x(t) = -\ h_o\ e^{g_1 t} - \sum_{i\ \{I/g_1\}} \{h_i \cos \beta_i t + h_i' \sin \beta_i t\}\ e^{\alpha_i t},$$

$$\forall\ t \in [0,\ +\infty]$$

where $s_j = g_1 > \alpha_i$ and $s_i = \alpha \pm i\, \beta_i$ $\forall i \in \{I/g_1\}$

s_i are the roots of

$$15.3) \quad \int_{o}^{n-k_1} d_1(u)\, e^{-su}\, du = 0 \; ; \quad \forall s \in S$$

S being the region of the complex plane for which the LT of $d_i(\cdot)$ exists. Note, also, that g_1 is its only real and positive root. h_o, h_i, h_i' are constants. It is a sufficient condition for h_o to be negative that the number of starts of the old process, $x_o(t)$, be positive, a condition which is clearly satisfied in this case since its solution is a steady state one. This is of importance to determine convergence to and local stability of an economically feasible path. 15.2) exhibits the following characteristics:

(i) for $t \to \infty$ it converges to the new steady-state solution since $g_1 > s_i$ $i \in I$;

(ii) it may have negative solutions, the so called Hayek effect (for a discussion of which see Hicks (1973) and Zarmagni (1984)), and a fortiori solutions which for intervals of t are $x_1(t) \leq x_o(t)$;

(iii) the existence of complex roots is a necessary condition for the Hayek effect to occur.

While the practical significance of Hayek effects is difficult to perceive, beyond the fact that they signal a state of extreme economic distress and the actual running down of accumulated stock, $x_1(t) \leq x_o(t)$ is of simpler interpretation. This depends, as the mere inspection of parameters in 15.2) shown in the Appendix indicates, on the profile of $d_o(u)$ relatively to $d_1(u)$. Indeed, the lower is the latter in relation to the former, the greater is the likelihood that traverse activity levels be lower than in the reference path. This is the case when the more backward lying phases of the process are the most labour intensive and lower debt instalments, z_1, do not offset higher labour costs. Lower activity levels and Hayek effects can generally be ascribed to a shortage of the economy basic resource to carry out industrialization: the available wage fund, given the social consumption target. They are, obviously, very critical states. A way out, independently of foreign aid, of course exists: the country must be willing and able to diminish consumption per head or to turn terms of trade against agriculture to support industrial wages. The economic hardship and political disarray these policies cause are well illustrated by the historical experience of many countries.

The implication of change on debt can be seen by reference to 13) and 13.1). D(t) converges to a new steady--state with a lower P_1 and a higher growth rate g_1, its path being governed by $x_1(t)$.

IV. **Productivity linked repayment**

The problems discussed above occur as the mere consequence of a longer production process. The scope of attempting to establish a capital making phase domestically, however, lies with productivity growth stemming from learning. Its effect must now be dealt with. The discussion is restricted to a learning process which reduces labour inputs $a(k_j+u)$, $j=0,1,...\vartheta$, as the time of activity operation evolves. This effect could be modelled analitically by setting such inputs as a function of cumulated activity levels (Amendola and Gaffard, 1988). For the purpose of the following discussion, however, it is sufficient to consider $a(k_j+u)$'s as time functions having certain characteristics. First of all the process of learning is upper bounded: $a(k_j+u)$'s fall to a given minimum. Further productivity gains can be obtained only by deepening the capital making period, i.e. by switching to earlier phases of the process. This means enlarging the capital goods industry. The functions can be written as:

16.) $$a(t,k_j+u) = \bar{a}(j,k_j+u) - \Phi_j(t,k_j+n)$$

where: $\bar{a}(j,k_j+u)$ is the input initially needed at $t=j$ when the phase beginning at k_j is started. Furthermore, $\bar{a}(j,k_j+u) = a(j,k_{j-1}+u)$: the initial input is inherited from the previous phase, $j \le t_j$,

$$0 \le \Phi(t,k_j+u) \le \bar{\Phi}_j < \bar{a}(j,k_j+u), \text{ for } j \le t \le t_{j+1} \;;\; \Phi_j'(\cdot) \ge 0 \;;$$

Given the current technology there is an $a^*(k_j+u)$ which marks a lower limit to the entire process (Fig. 2). The function which has been illustrated is quite general and can fit several learning patterns. It rules out, however, «forgetting» which could, in fact, be a serious threat. This phenomenon might actually happen if the economy were to undergo a period, during a traverse, of falling activity levels.

To the extent that the productivity gains described above actually take place, a strategy can be undertaken aimed at linking debt servicing to them. Variable instalments can then be envisaged reflecting the country's changing economic conditions. This can be done by setting the instalments as a time function deviced in such a manner as to keep the sum of labour and financial costs constant. Hence, if $\bar{z}_j$ is the debt instalment at time j, then:

$$17.)\qquad z(t,k_j+u) = \bar{z}_j + \tilde{w}\Phi_j(t,k_j+u) \qquad \text{for } u \in [o,m_j]$$

where $z_j = z(j,k_{j-1}+u)$ and $z(\cdot) = 0$ for $u \in [m_j,n-k_j]$. From the point of view of financial conditions, for any given interest rate, the maturity of loans stipulated at different periods varies. Indeed, terms on purchases of the same segment $[0,k_j]$ occurring, say, at $t = j$ and at any other t, must satisfy the following:

$$P_j = \int_0^{m(j)} z(j+\tau,\ k_j+\tau)\ e^{-i\tau}\ d\tau \qquad \text{and}$$

17.1)

$$P_j = \int_0^{m(t)} z(t+\tau,\ k_j+\tau)\ e^{-i\tau}\ d\tau$$

By Leibnitz' rule it is easily seen that $dm/dt < 0$. The above implies that the process cost at stage k_j+u of completion is:

17.2) $$\tilde{w}\ \bar{a}_j(j,k_j+u) + \bar{z}_j = c(k_j+u)$$

which is constant with respect to t, for $j \le t < j+\tilde{m}(t)$ where $\tilde{m}(t) = \max\ \{m(t-u)\},\ u \in [0,\tilde{n}(t)-k_j]$.

Since each new loan features its own maturity, $m(t)$, full-performance equation 11.) must be amended as follows:

18.) $$P_j = \int_{t-[\tilde{n}(t)-k_j]}^{t} b(k_j+t-u)\ x_j(u)\ du - \tilde{w} \int_{t-[\tilde{n}(t)-k_j]}^{t} a(t,k_j+t-u)\ x_j(u)\ du =$$

$$= \int_{t-\tilde{m}(t)}^{t} z_j(t,k_j+t-u)\ x_j(u)\ du$$

where the RHS is the amount of net exports required to service debt at time t. The reason why the lower integration bound is $\tilde{n}(t)$ rather than n is that truncation varies with time. When a new process is started, a decision is to be made on its duration knowing with certainty the future labour and financial costs according to 16.) and 17.). Profiles are time variables and thus a process beginning at t will be truncated accordingly. Thus, $\tilde{n}(t) = \max n(t-u);\ u \in [0, n-k_j]$. Similarly, there is the problem of when to start a new phase. Processes activated in the neighborhood of t_{j+1} experience increasing returns for a very short span of their lifetime. The criterion of the growth rate maximization can be restated in this context, where rates vary, by assuming that each process maximizes its own rate of return given per capita consumption $\tilde{w}$ and instalments $z_j(t,\cdot)$ with maturity m(t). A switch to a new phase occurs when a process j+1 inheriting initial labour inputs from j but with increasing returns for the whole, or most of its lifetime, exhibits at least an equal rate of return. Given the full knowledge of 16.) and 17), a calendar of switch points j follows immediately.

Consider now outstanding debt. On account of 13.)

$$19.)\quad D(t) = P_j \int_0^{\tilde{m}(t)} e^{iu} x(t-u)\, du - \int_0^{\tilde{m}(t)} \left[\int_0^{u} z(t-\tau, k_j+\tau)\, e^{i\tau}\, d\tau \right] x(t-u)\, du$$

If $z(\cdot)$ had no upper bound and since $\dot{z}(\cdot) > 0$ while $\dot{m}(t) < 0$, there would certainly exist a t* for which $\dot{D}(t^*) = 0$ and past which $\dot{D}(t) < 0$; eventually $D(t) = 0$. Switching to earlier phases, however, implies that $z(\cdot)$ goes on increasing insuring that

$$20.) \qquad \lim_{t\to\infty} D(t) = 0 \ ,$$

The situation described by 18.) is not adequate. Problems, in fact, arise since the economy will have in operation processes beginning at different phases. It is, again, a problem of traverse. Take the simplest case of processes beginning at two different phases. Analogously to 14), full performance must take into account processes beginning at k_{j-1} and still in operation at time of switch j^* and new ones, beginning a k_j, still in operation at time t. Comparison can then be made with an equation such as 18.) for phase (j-1,j) assuming that no switch had occurred, i.e. with a reference path. By subtracting

$$21.) \quad \int_j^t d_j(t,t-u)\ x_j(u)\ du = \int_j^t d_{j-1}(t,t-u)\ x_{j-1}(u)\ du$$

where $d_{j-i}(t,t-u)=b(k_{j-i}+t-u)-\tilde{w}a(t,k_{j-i}+t-u)-z_{j-i}(t,k_{j-i}+t-u)$ for i = 0,1. Solving for $x_j(t)$ in 21.) carries an additional difficulty: net proceeds from processes, $d_{j-i}(t,u)$, are now time variables. The analysis can, however, be simplified by resorting to a stepwise approximation of the learning curve. In this case, $d_{j-i}(t,u)$ can be taken as invariant within specified time segments (t_{v-1},t_v). By indicating with $d_{j-i}(v,u)$ such constants 21.) can be transformed into a sequence of

$$21.1) \quad \int_{t_{v-1}}^{t_v} d_j(v,t-u)\ \bar{x}_j(u)\ du = \int_{t_{v-1}}^{t_v} d_{j-1}(v,t-u)\ \bar{x}_{j-1}(u)\ du$$

which lends itself to solution by an LT procedure in all points similar to 15.1). it is interesting to note the following:

i) the highest root of

$$\int_{o}^{n(v)-k_j} d_j(v,u)\ e^{-su}\ du = 0\ ,$$

$g_j(v)$ is a steady state solution to which 21.1) converges provided $\bar{x}_{j-1}(t)$ on the reference path is positive. It is also $g_j(v+1) \geq g_j(v)$, $\forall$ v, since $d_j(v+1,u) \geq d_j(v,u)$ on account of increasing returns;

(ii) Hayek effects and $\bar{x}_j(t) \leq \bar{x}_{j-1}(t)$ are both possible since complex roots are quite likely;

(iii) the actual activity path $x_j(t)$ is an envelope of the $\bar{x}_j(t)$s.

While outstanding debt will eventually be exstinguished the economy may undergo periods of highly critical behaviour with strong fluctuations in activity levels. Debt itself, for the part explained by the latter, is subject to a similar pattern.

V. Summary and conclusions

Breaking the vicious circle of low productivity and slow growth is an issue of paramount importance for development. The paper addresses this problem by inquiring into a strategy whose initial step is the import of capital goods and related transfer of technology financed by borrowing on external markets. Following steps aim at gradual import substitution and productivity linked debt repayment. The basic problem lies with consistency between financial terms and the economy production profile. This is analyzed by means of an integrated neo-austrian model. Results can be summarized as follows:

1. Repayment conditions establish an interest rate, consumption per head trade-off. If interest rates and maturities are set by lenders, living standards must adjust, possibly at levels below subsistence.

2. The above relationship is jointly defined by the technical and temporal profile of production processes: any change requires either an adjustment of financial terms or of living standards.

3. Consumption per head and the period debt instalment define, in the case of steady state, a consumption per head growth rate trade off. Conbining this with the former determines an interest rate, growth rate relationship. Because living conditions act as an adjusting buffer, the latter may be positive in a well defined range of the rate of interest.

Outside, it is an inverse relation in spite of worsening consumption per head.

4. A mounting outstanding debt cannot be sustained. If the developing country is to check its growth it will have to resort to domestic production of capital making segments. Moving from one state to another implies a traverse in which falling activity levels and Hayek effects can both occur even if convergence to a higher steady state is insured. Preventing this requires further lenders' flexibility.

5. Learning increases productivity. Falling labour inputs allow to increase instalments keeping total process cost constant. The rising capability to service debt and shorter maturities insure that outstanding debt will eventually vanish. The basic problem remains traverse which exhibits similar characterstics as in 4.

Structural change and self-reliance require a painful process of adjustment. Credit plays a crucial role in permitting both and in easing their consequences. As historical experience shows, however, structural disequilibria are too often conceived as a problem of financial soundness. Policies deviced accordingly may hamper development goals.

Our analysis does not carry specific normative rules. We hope to have made the point, however, that financial support must be consistent with development efforts. Whether the international financial establishment is willing to comply with such a course is open to serious skepticism.

Appendix

The solution of 15.1

$$15.1) \quad \int_{o}^{t} d_o(t-u)\; x(o)\; e^{gt}\, du = \int_{o}^{t} d_1(t-u)\; x_1(u)\; du \qquad t \quad (0,\infty);$$

for $x_1(t)$ can be obtained by resorting to a Laplace Transformation (LT). Since the LT of a function f(u) is $L[f(u)] = \int_o^{\infty} f(u)\; e^{-su}\, du$, 15.1) can be transformed in the following canonical form:

$$15'.1) \quad L[x_1(u),s] = \frac{L[d(k_o+u),s] \cdot L[x_o(u),s]}{L[d(k_1+u),s]}$$

By applying the inversion theorem,

$$15'.2) \quad x_1(t) = \lim_{\beta\to\infty} \frac{1}{2\pi i} \int_{\bar{\alpha}-i\beta}^{\bar{\alpha}+i\beta} \frac{L[d(k_o+u),s] \cdot L[x_o(u,s)]}{L[d(k_1+u),s]}\, e^{st} ds$$

where $s_j = g_1 > \alpha_i$; $s_i = \alpha_i \pm i\beta_i$; $i \neq j$; $\bar{\alpha} > \max_{i\; I} RE(s_i)$;

The integral in 15'.2) can be solved by the Cauchy theorem of residuals (Apostol 1977) leading to:

15.3) $$x_1(t) = - \frac{\int_0^{n-k_o} d(k_o+u)\, e^{-g_1 u}\, du \int_0^{\infty} x_o(u)\, e^{-g_1 u}\, du}{\int_0^{n-k_1} \int_{\tau}^{n-k_1} d(k_1+\tau)\, e^{-s_i \tau}\, d\tau\, du}\, e^{g_1 t} -$$

$$- \sum_{i \in \{I/r\}} \frac{\int_0^{n-k_o} d(k_o+u)\, e^{-s_i u}\, du \int_0^{\infty} x_o(u)\, e^{-s_i u}\, du}{\int_0^{n-k_1} \int_{\tau}^{n-k_1} d(k_1+\tau)\, e^{-s_i \tau}\, d\tau\, du}\, e^{s_i t}$$

Note the following:

1.) $$h_o = - \frac{\int_0^{n-k_o} d(k_o+u)\, e^{-g_1 u}\, du \int_0^{\infty} x_o(u)\, e^{-g_1 u}\, du}{\int_0^{n-k_1} \int_{\tau}^{n-k_1} d(k_1+\tau)\, e^{-s_i \tau}\, d\tau\, du}$$

2.) $$\int_0^{n-k_o} d(k_o+u)\, e^{-g_1 u}\, du < 0$$ since

$g_1 > 0$ is the highest positive root of

2.) $$\int_{o}^{n-k_1} d_1(u)\, e^{-su}\, du = 0$$

3.) h_i and $h_i^!$ are constants. Their expression as well as the derivation of the sum in 15.2) can be found in Violi (1985).

NOTES:

(1) From 7. and 8., it is:

(i) $$\int_{o}^{n_a-k_o} q_a(k_o+u)\, e^{-\hat{r}u}\, du = z_o \int_{o}^{m} e^{-iu}\, du$$

The actual rate of return r* obtained by operating a process on borrowed funds is set by:

(ii) $$\int_{o}^{n_a-k_o} q_a(k_o+u)\, e^{-r^*u}\, du = z_o \int_{o}^{m} e^{-r^*u}\, du$$

(i) and (ii) imply:

(iii) $$\int_{o}^{n_a-k_o} [q_a(k_o+u)\, e^{-(\hat{r}-i)u} - z_o(u)]\, e^{-iu}\, du = \int_{o}^{n_a-k_o} [q_a(k_o+u)-z_o(u)]\, e^{-r^*u}\, du$$

$$\text{where } z_o(u) = \begin{cases} z_o & \text{for } u = (0,m) \\ 0 & \text{for } u = (m,n_a-k_o) \end{cases} \qquad \text{if } m \le n_a-k_o$$

If $\hat{r}>i$, (iii) requires that $i<r^*$ $\hat{r}-i>0$. On account of (i) and (ii) however, this means:

$$\int_o^{n_a-k_o} q_a(k_o+u)\ e^{-\hat{r}u}\ du > \int_o^{n_a-k_o} q_a(k_o+u)\ e^{-r^*u}\ du$$

implying $r^*>\hat{r}$ contradicting $\hat{r}$=max because of free truncation. Analogously if $\hat{r}<i$, $\hat{r}>r^*$ satisfying $\hat{r}$=max. In this case, however, an additional condition insuring repayment must be introduced; it must, at least, be verified:

$$\text{(iv)} \qquad \int_o^{n_a-k_o} q_a(k_o+u)\ e^{-iu}\ du = P_o$$

which cannot be if (i) holds.

If follows that $\hat{r}=i=r^*$ which satisfies (iii).

This result means that in equilibrium operating the entire $(0,n_a)$ period or starting from k_o on borrowed funds is indifferent. (iv), in reality, must hold for a span m of time, the debt maturity period:

$$\text{(v)} \qquad \int_o^{m} q_a(k_o+u)\ e^{-iu}\ du = P_o;$$

But if this holds together with (i), being $i=\hat{r}$, then if $m<n_a-k_o$, it follows:

$$(v) \qquad \int_m^{n_a-k_o} q(k_o+u)\, e^{-\hat{r}u}\, du = 0$$

which is contrary to assumption. Similarly if $m>n_a-k_o$,

$$(v) \qquad \int_{n_a-k_o}^{m} q_a(k_o+u)\, e^{-iu}\, du = 0$$

which implies inability to repay in the last leg of the [0,m] period. Hence $m=n_a-k_o$.

(2) Considering 13.)

$$D(t) = \int_o^m P(u)\, x(t-u)\, du$$

and by simple manipulations:

$$D(t) = \frac{P_o}{i-e^{-im}} \left(\frac{1-e^{-g_o m}}{g_o} - e^{im} \frac{1-e^{-(g_o-i)m}}{g_o-i} \right) x(t)$$

thus the multiplicand of x(t) in the RHS is $C(P_o,m,g,i)$.

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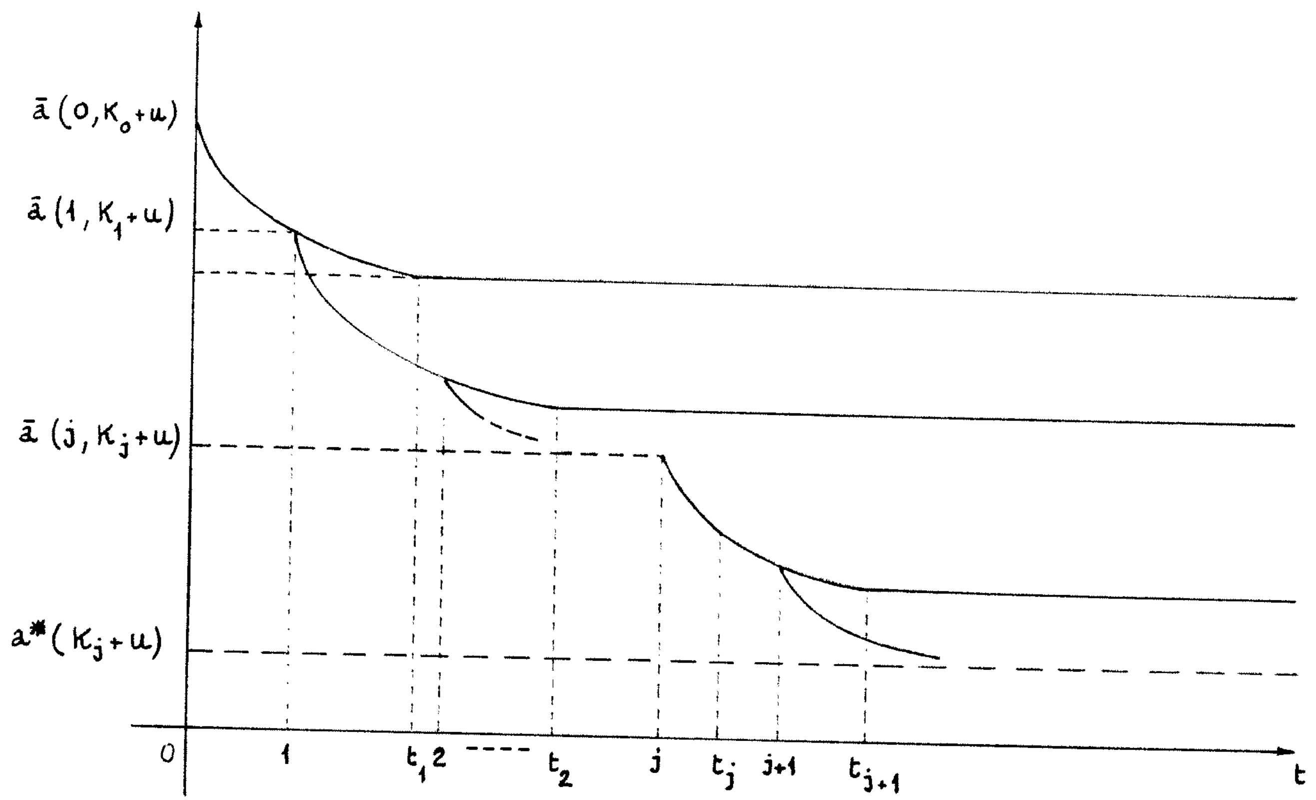

FIG. 2

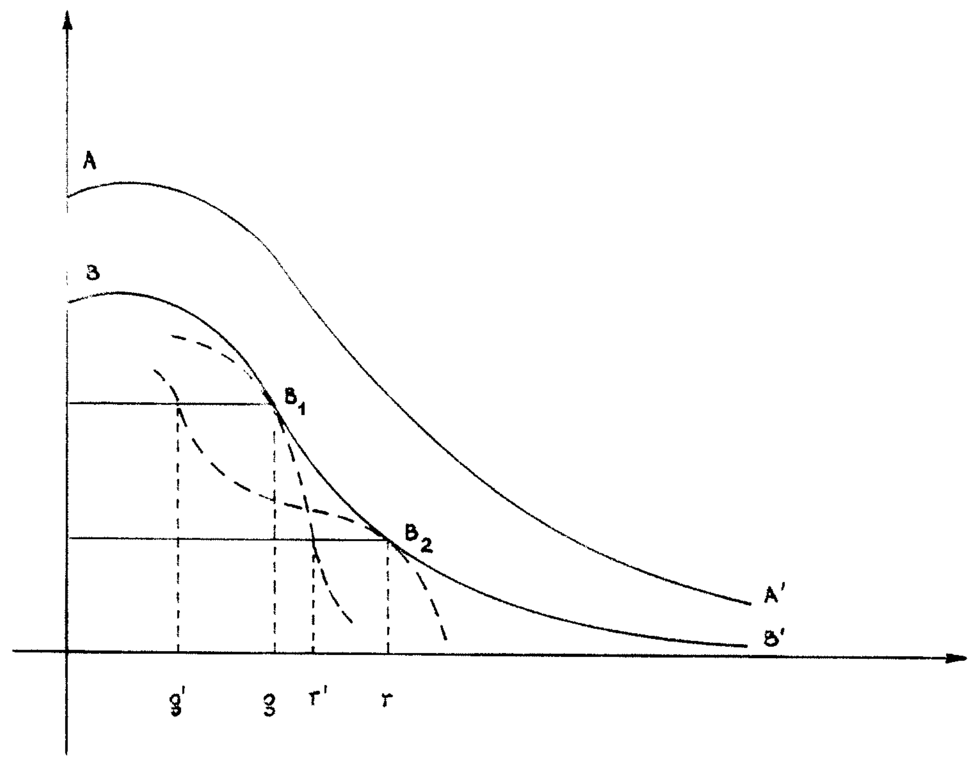

FIG. 1