Title	A theoretical analysis on economic growth and resource exploitation : expansion of the classical-school model
Sub Title	
Author	白石, 孝(Shiraishi, Takashi)
Publisher	
Publication year	1977
Jtitle	Keio business review Vol.14, (1977.) ,p.1- 17
JaLC DOI	
Abstract	
Notes	
Genre	Journal Article
URL	https://koara.lib.keio.ac.jp/xoonips/modules/xoonips/detail.php?koara_id=AA00260481-19770000-03920027

A THEORETICAL ANALYSIS ON ECONOMIC GROWTH AND RESOURCE EXPLOITATION

——Expansion of the Classical-School Model——

by

Takashi Shiraishi

I. *Prologue*

The growth of economy in the developed countries of the world since the second half of the 1950s has been of course grounded on the varietiful technical progresses, building the present industrial structures, and the inter-industry transfer of production resources necessary for such growth. Yet on the other hand we must mention the fact that basic materials of world-wide need have been supplied at relatively low prices and with stability.

Oil had entered an over-supply epoch in the world markets already by 1953 and, with various unfavorable factors gathering, in 1959–60 its official prices in the producing countries had to be decreased as large as by 15 percent on average conforming to the positive market prices. Copper also suffered prolonged price stagnation from 1957 through 1964, leading to voluntary output curtailment by producers and price-support buying by the LME. As for nickel fairly stable prices were sustained from 1959 to 1966 due to its particularity, being higher than in the second half of the 1950s. This was also the case with bauxite. The essential fact was that the prices of primary goods had been generally at a low level in the second half of the 1950s, as is clearly told by the moves of Reuter's index number. Although there was a temporary rise at the time of the Suez Canal Incident, for the subsequent several years the index number doubtlessly tended to the lower. This invited a problem of unfavorable terms of trade for the developing countries exporting primary goods, but worked as a factor to realize growth in the developed countries seeing a new growth period. Indeed cheap and abundant supply of basic materials facilitated expansion of production scales, and did well offset inflationary effects often born from time lag of creation between production capacity and demand at the stage of growth. Furthermore, it is supposable that meanwhile rises in the level of real income were realized.

However, these situations were changed in the second half of the 1960s. The price of basic materials turned to a trend of increase with expanding amplitude of swings. The inflation in the developed countries had left a phase of creeping already by 1969, thereafter accelerating itself year after year, to which in 1972 was added a sharp rise in the price of primary goods. The supply-demand balance in the world markets of basic materials came to face big fluctuations. Thus there is now a possibility of severe fall in the growth rate of economy of many countries, which may probably deserve to be called a turn of the postwar long-run growth cycle.

Against such backgrounds people have come to renew their consciousness on the problem of economic growth vs. resources, its long-run prospect making the focus of attention. Programs of resource exploitation should be considered from a long-run viewpoint. Anyhow it is fundamental to explore through what mechanism economic growth and resource exploitation are interrelated. There, of course the approach may be divided: either to grasp the supply-demand balance within the prospect of physical scarcity-tendency of resources, or to look the balance as cycle gaps, that is, gaps between the rate of resource exploitation and the cycle of economic growth. The former is right what makes a presupposition in the classic model, whose expansion is intended in this study. Yet the fact is unignorable that the rate of resource exploitation is cyclical so long as it is an economic activity. To observe historically, resource exploitation was advanced in the first half of the 1950s mainly by American capital, which brought about increased supply in the second half. As the result prices decreased, adjustment of production was conducted, and the rate of new investment and exploitation dropped. In this sense in the mid-1960s there was a trend-down of exploitation, while on the other hand at that period the cycle of economic growth inversely turned to a trend-up, with the growth rate increasing. Hence it would not be amiss to look that therein a cycle gap between resource exploitation and economic growth is observable.

From these viewpoints in this paper we will firstly deal with positioning of resource exploitation within the mechanism of long-run growth by the formula of the classic model, next to clarify the results of the promoted scarcity-tendency of resources, and then to consider what course of expansion would be taken by resource industries and what cycle gap would be borne by the growth rates of supply and demand.

II. Economic Growth and the Scarcity-Tendency of Resources

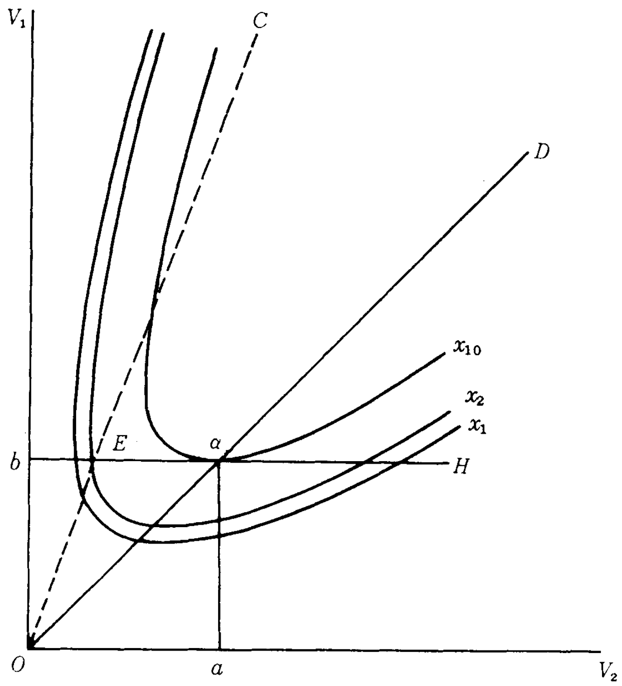
——the classical model——

Here what we immediately think of is the classical model of economic growth. It is because the pattern of economic growth pictured by the classical-school economists such as Ricardo and Malthus contains the scarcity-tendency of resources as a presupposition.[1)]

There the production function is $x=f(V_1, V_2, T)$. V_1 stands for land, V_2 for labor and capital, and T for technical progress. Usually labor and capital are separately treated as factors of production, but here we group them as V_2, representing real costs, in order to make clear the effects of the scarcity-tendency

1) See writer, Some Effect of the Scarcity Tendency of Resources on Economic Development, *Mita Shōgaku Kenkyu,* Vol. 12, No. 3, 1969, pp. 44–59.

Figure 1



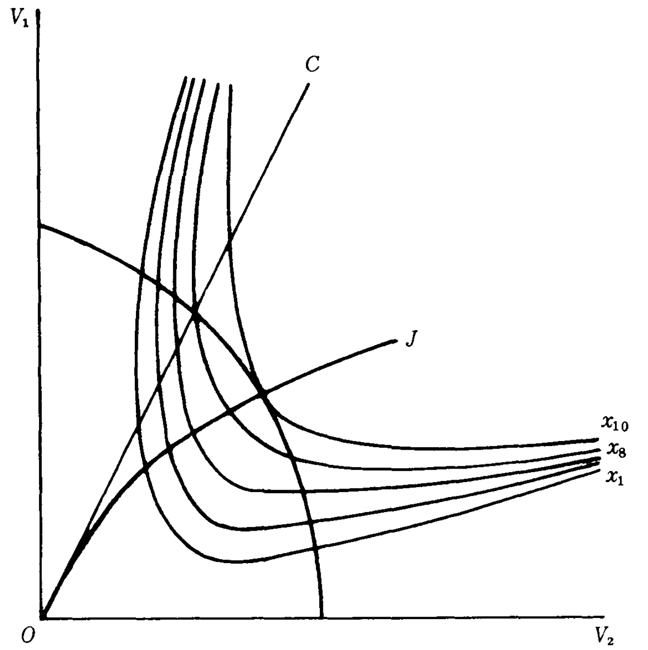
of resources in question. If no technical progress is assumed, output is determined solely by V_1 and V_2. However, a difference of nature lies between the two. That is, while V_2 may increase its existing quantity in the course of time, V_1 is limited in quantity and may become scarce relatively to V_2. The classic model stands on a strong emphasis of this presupposition, and today the so-called Rome Club appears to take this view. Once Malthus has said the breadth of land is limited, impossible to expand by human desires: again the unequality of soil causes relative scarcity of superior land even at the early period of society.[2)]

Now on this presupposition we draw an isoquants map, Figure 1.[3)] As is seen, taking the X-axis for V_1 and the Y-axis V_2, a certain isometric volume of output by the combination of the two factors is shown as x_1, x_2,.... In usual cases V_1 and V_2 can be conceived two homogeneous factors and hence their rational combination must lie between two lines, *OC* and *OD*. But here V_1 is a particular factor, natural resource =land. If its limitless existence were assumed, the optimum use would be utilization up to a point where its marginal productivity becomes null because no additional input of labor or capital would be required, that is, its price or real costs are zero. By seeking such points respectively corresponding to the variable quantities of V_2, an expansion passage will be drawn. *OC* in the diagram is this.

2) R. Malthus, Corn Law, Japanese translation by Kōichiro Suzuki, *Kokumotsu Jōrei Ron*, p. 67.

3) As to Figure 1 and 2 see Barnett, H. J. and C. Morse, *Scarcity and Growth*, 1963, p. 288.

Figure 2



On the contrary if land were limited in quantity as mentoined above, V_1 would become fixed at a certain boundary. Let's show this by *Ob*. Of course, up to this boundary no quantitative limitation exists on V_1 and so the expansion passage agrees with *OC*. Once the use of V_1 reaches *Ob*, however, the expansion passage can no longer travel on *OC* but changes to *OEH*. And, coming to α, total output does not increase but decrease absolutely even if V_2 is put in further. Thus the isoquant X_{10} represents the level beyond which production cannot expand, however much labor and capital are added.

However, it would be more realistic, instead of assuming such simple limitedness of existing quantity, to consider the matter of resource scarcity in a form of worsening quality. For we have many cases of fertility deterioration by expanded cultivation or diminishing contents in mineral resource exploitation.

Figure 2 is an isoquants map based on this assumption. While in the former diagram V_1 was measured as homogeneous physical units, here V_1 itself is considered a "heterogeneous resource," in other words units of declining quality. Now, accordingly, in order to get a certain volume of output, input of more labor-capital to be combined is required, and that, this increment of input must be greater than the increment of V_1. So the expansion passage shapes *OJ*, different from the former *OC*. And if V_1 is limited, *OJ* will become parallel to the Y-axis after passing the limit.

Anyhow, what these two classical models tell us are that, as regards natural-resource-intensive goods (or industries) the real costs shown by V_2 have tendency to increase in accompany with increases in output, that consequently their prices generally rise provided other things are equal, and further that, when the limit of existence is reached, output stops to increase and turns to decline notwithstanding any additional input of labor-capital. However, even if this may be a theorem concerning with primary goods (industries), in the classical model they are "wages goods" and it is intended to show that price increases in these goods bring about wage increases and profit decreases, leading to a static position in the ultimate. Further analysis of this process, however, is not our aim here. Rather we should like to focus our attention on the possible expansion of this model regarding two sectors.

The presuppositions of this model, according to Ricardo, are as follows.

(1) Goods of a society capable of reproduction consist of two sorts; one which are limited by the productivity of land and whose additional production requires more labor, and one for which labor for additional production can be diminished through improvements of machinery, skills, and division or allocation of labor.

(2) The former-group goods make up the major part of necessities to support manpower, and their price administers the price of labor. Of course they affect the remuneration of labor to be put in the production of the latter-group and in the end administer the costs. However, for the latter goods, if the price of the former has risen, it is possible to introduce machinery, to diminish labor, thus to offset increases in the costs and rather to lower the price.

(3) Thus, to look as the long-run, the former goods tend to rise in price while the latter to decline. And the long-run price tendencies of the two are interrelated. The tendency of the former continuously works on the latter toward machinery utilization, productivity improvement and the decrease of relative price, along with capital transfers for competition.

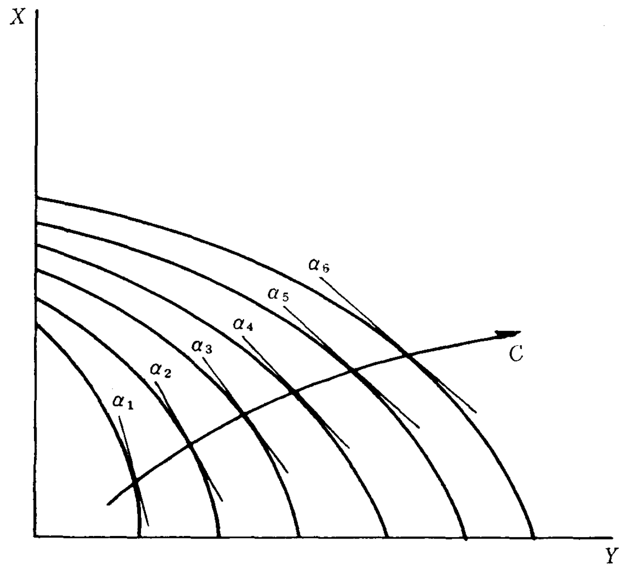
Now, let's name these two sorts of goods (industries) X and Y. To consider their relative prices along the process of economic growth, we can draw Figure 3.[4]

Needless to say economic growth is expressed as upward shifts of the produtcion-possibility curve. Since by the presupposition (1) the increment of goods X is smaller than that of goods Y, the production-possibility curve has a pattern as shown in the picture, and the growth path, connecting the equilibrium points between production and consumption, bends as OC (provided consumers' preference to the two goods are unchanged) while the slope of the curve α, representing the relative price, becomes less and less acute as from α_1 to α_2, from α_2 to α_3. In other words, goods Y reltaively decline in price against X through the process of growth.

However, it will be necessary to consider here again why goods X rise in price more than goods Y. The very reason is that, as mentioned in the presupposition (2), technical progresses are induced so that the price increases in Y

4) In Vanek, J., *The Natural Resource Content of United States Foreign Trade*, 1870–1955, (1963) such expansion of the production-possibility curve is supposed for 1870–80 and 1950–55.

Figure 3



are offset in the Y-sector on costs. That is to say, this model, supposing little room for technical progress in the X-sector, considers it principally with respect to the Y-sector to bring about decreases in real costs. Of course technical progresses may spontaneously arise, but the essential point is that such progresses as are induced by the price increases in goods X are assumed to be inevitable as the behavioral principle of capital. So, it must be said, although the relative price may be considered to change on the same direction in the long-run, in this process various conditions will be entered and the growth path OC will not always take the shape shown, while the relative price will not necessary move on the same direction. One of such conditions is on the demand side and another is the matter and pace of technical progress. Nevertheless we could pick up the following points from the classical model.

(1) Economic growth depends not only on the state of existence or the growth rate of production factors such as labor and capital but also on natural resources, and the scarcity-tendency of the latter must be presupposed through the process of growth.

(2) The scarcity-tendency of natural resources has two aspects. The one is that their productivity declines due to "heterogeneity" and hence real costs, i.e. per-unit input of labor and capital, tend to increase. The other is that due to "limitedness" physical constraints lie in the expansion of output.

(3) As the result of these, economic growth involves a possibility of reaching a static state by reason of increases in wage rates. On the other hand, in accompany with the aggravation of resource scarcity, the price structure tends to relatively high prices in the resource industry as against manufacturing, which drives the latter to technical progresses to cover increases in the factor price. This is reflected in the relative price between the two sectors, with the resource sector becoming more and more unfavorable.

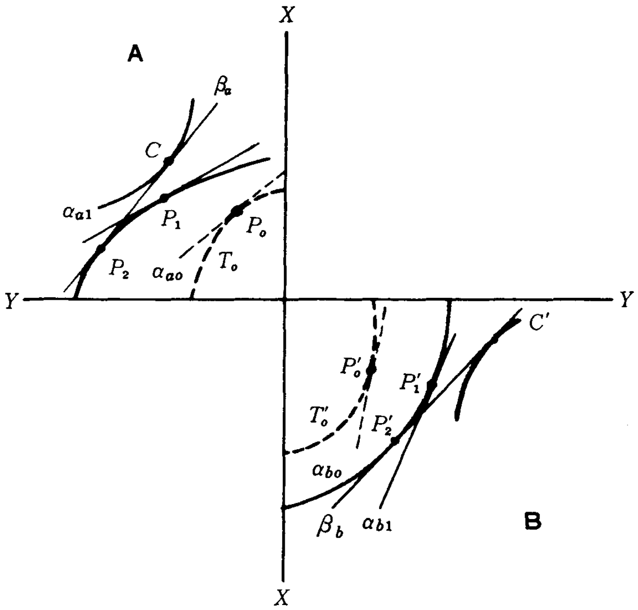
III. Resource Scarcity-Tendency under Free Trade

——expansion of the classic model open system——

To consider the above-examined classic model as the open system, what results can we derive?

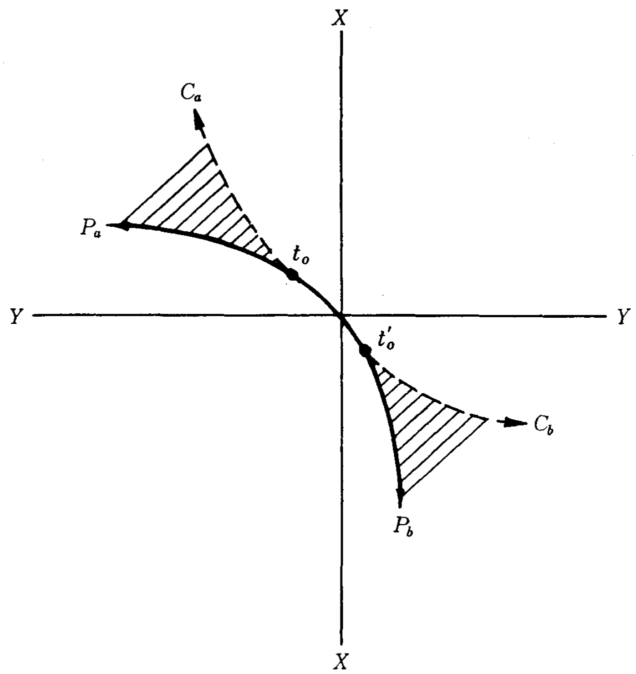
Supposing two countries (A, B), two goods (X, Y) and two factors (V_1, V_2), we draw Figure 4.

Figure 4



The production-consumption-price structures in countries A and B are exhibited respectively in the second and fourth quadrants. T_0 and T_0' are the production-possibility curves at the outset. It is assumed that in country B the existing quantity of resources necessary to produce goods X is richer than in country A. Again let's assume that the indifference curve of consumption has the same shape for both countries and undergoes no change through the growth process. The production-consumption equilibrium point at the outset is P_0 (and P_0'), which in the course of time moves to a new point $P_1(P_1')$ with an upward shift of the production-possibility curve. By the classic-model supposition at period t_1 the production-possibility curve will show bias to goods Y rather than to goods X in both countries, as is seen in the figure. Accordingly the relative price between the two goods must come to have a more oblique slope from α_{a0} to α_{a1} (from α_{b0} to α_{b1}). In country$A$ goods X will become cheaper than was at the outset, while in country B goods Y will become so. If the $X-Y$ price ratio has a differential of $\frac{X_{p1}}{Y_{p1}} > \frac{X'_{p1}}{Y'_{p1}}$ between the two countries, Y is relatively cheap

Figure 5

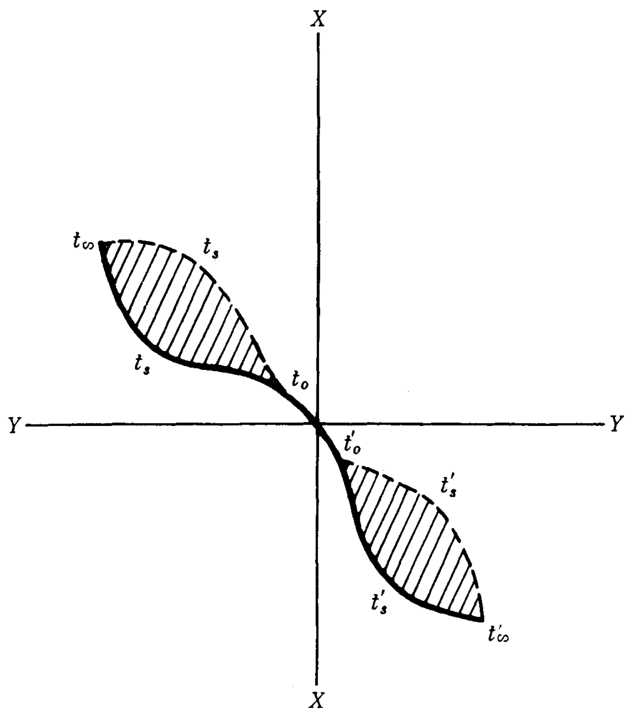


in A and so is X in B, and the two goods are traded each other. If as the result the terms of trade β are laid, the domestic price ratio becomes β_a in country A (β_b in country B), and consequently the production point shifts from P_1 to P_2 (from P_1' to P_2'), and the consumption point to C (C'). This is a familiar illustration of the advantages of free trade, for both countries can consume a larger quantity of goods than before by the same production frontier, provided country A produces more Y and country B more X.

The problem is the case of economic growth under the same terms of trade. To depict economic growth as the expansion of the production fronteier, the loci of the production and consumption points represent the curves showing respective courses of expansion. Figure 5 exhibits the production expansion passages P_a (P_b) and the consumption expansion passage C_a (C_b). Of course the gap between P_a and C_a (P_b and C_b) shows the volume of trade. This gap grows wider with economic growth, that is, the scale of trade expands, as the shadows in the figure show.

However, since goods X are by assumption natural-resource-intensive goods, in country B where their production is expanding, real costs will rise as mentioned above, and the shape of the production-possibility curve will be changed in course of time. In some case this may appear as a change in the rate of substitution of production in that country, and in another as that in the rate of possible increases in the two goods at an upward shift of the production possibility curve. On the other hand in country A, since the increase in the consumption of goods X is provided by imports, such production factor as is primarily to be put in goods

Figure 6



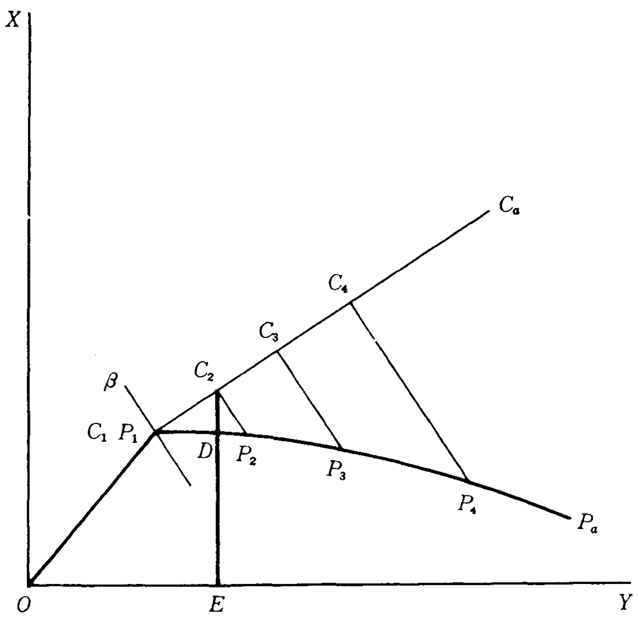
X will be transfered to the production of goods Y. Yet in this transfer the quantity of natural resources V_1 will be relatively small compared with V_2 (labor and capital) due to a difference of the intensity of factors. Accordingly the scarcity of natural resources will advance only slowly relatively to economic growth, and its real costs will not increase so much. Thus, putting aside the demand side and technical progresses, as in Figure 6, trade diminishes after t_s for both countries and comes to stop sooner or later, theoretically speaking. No inverse trade flows can arise due to the nature of goods X.

As the above simplified case may tell, if on natural resources such limitations as are in the classic model should be taken into account, we must say even free trade cannot solve this bottleneck unless it is accompanied by some other conditions. That J. S. Mill took technical progresses as alternative to free trade in this connection may have been an argument true applicable up to the point t_s. However, in view of the fact that such bottlenecks of resource have appeared but then disappeared, we must take into consideration not only the effect of free trade but also technical progresses that have always been contemplated on the other hand.

However, before going into technical progresses, here we should like to examine a little further the cases of this open system.

In the foregoing analysis we have pointed out that, in accompany with economic growth under the open system, trade expands until the point t_s is reached. This means that, speaking generally, the more the resource scarcity of a country is

Figure 7



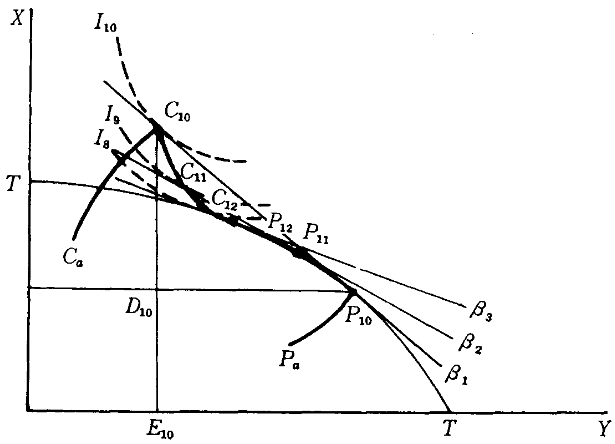
aggravated, the lower becomes its rate of self-sufficiency, provided the terms of trade are constant. Self-sufficiency is of course $\frac{ED}{EC_2}$ as in Figure 7. Here its decline is larger than in usual cases, that is, where no resource scarcity is taken into consideration. This is because the production-possibility curve shifts upward taking a pattern of gradual bias to goods Y.

In Figure 7, under the terms of trade β, by the change of the production point $P_1 \to P_2 \to P_3$..... and the curve-down of the line $P\alpha$, its locus, this decline in self-sufficiency is shown. The rate of self-sufficiency, however, must be varied according to the direction and shape of the consumption-expansion passage $C\alpha$. In case of two-goods model it will be determined by the shape of the indifference curve of consumption. Actually it is conceived to depend on the income elasticity of demand for goods X. That is, if its value is greater than unit the consumption point travels the left-upper side of the extended line of OP_1, and if smaller the right-lower side. By taking account of these conditions, the course of the self-sufficiency rate following economic growth can be decided.

Again if the terms of trade were changed to cause relative increases in the price of X, or if the stock of resources were increased due to the diminished production of goods X as mentioned above, then expanded production of X would be possible. By this, provided the propensity to consume is constant, the self-sufficiency rate would begin to rise showing the changes in Figure 6 ultimately.

However, prior to becoming like Figure 6, the following scene must appear. That is, as the result of aggravated resource scarcity the production-possibility curve ceases to shift upward beyond a certain limit. The curve TT in Figure 8

Figure 8



is right this marginal production possibility curve, on which, with the terms of trade being β_1, the production point is P_{10} and the consumption point is C_{10}. There the self-sufficiency rate is $\frac{E_{10}D_{10}}{E_{10}C_{10}}$.

Naturally at this stage country A is importing $C_{10}D_{10}$ of goods X. If the terms of trade have changed as $\beta_1 \rightarrow \beta_2 \rightarrow \beta_3$, since the production-possibility curve cannot shift upward, the production point has to move on this curve TT, say, from P_{10} to P_{11} at β_2 and further to P_{12} at β_3. At the same time the consumption point shifts right-downward as $C_{10} \rightarrow C_{11} \rightarrow C_{12}$. Thus the self-sufficiency rate will rise to near 100 percent. However, this means decline in the standard of welfare because the consumption point moves downward from I_{10} to $I_9 \rightarrow I_8$, intersect points with the indifference curve of consumption. In other words, the points P_{10} and C_{10} represent the limit of expansion with the standard of welfare being maximum, and the self-sufficiency rate $\frac{E_{10}D_{10}}{E_{10}C_{10}}$ is optimum. Any attempt to raise self-sufficiency would cause a decline in welfare. Hence the course will be either that the curves P_a and $C\alpha$ stop respectively at P_{10} and C_{10} before coming to trade stoppage (t_s in Figure 6) or that, if the terms of trade have worsened, the two curves bend to P_{12} and C_{12} resulting in trade stoppage and a welfare decline. There economic growth ceases at TT and, if there were further deterioration of the terms of trade, there would be nothing but a decline in the standard of welfare.

Thus, insofar as the expansion of the classic model under the open system is concerned, we can draw the following conclusions.

(1) Under free trade, through economic growth the scale of trade gradually expands, in accompany with which in the importer countries of resource-intensive goods the self-sufficiency rate decreases.

(2) However, on account of changes in the terms of trade and the pace of production expansion due to aggravated resource scarcity, imports of resource-

intensive goods decrease, leading to trade stoppage theoretically.

(3) If the limitedness of resources is assumed, expansion of production ceases for both X and Y, and before approaching to theoretical null trade, self-sufficiency rises due to the unfavorable terms of trade, yet with a inevitable decline in the welfare standard.

IV. Expansion Processes of Resource Industries and Technical Progresses

Now we will consider the effects of technical progress on the scarcity-tendency of resources.

In the above we took X for resource-intensive goods and formulated its production function as $O_x=f(V_1, V_2)$. And by expanding the classic model it was found that economic growth becomes limited by the aggravation of resource scarcity, that at this limit a rise in self-sufficiency causes rather a decline in welfare, and that if a country's terms of trade worsen due to the conditions of the X-exporter country, the former country inevitably raises self-sufficiency, which leads to a decline the standard of welfare.

Accordingly, if such situation is to be evaded as far as possible, technical progresses for resource saving in the production of goods X is necessary. It means enlargement of $\frac{\partial O_x}{\partial V_1}$. Or otherwise technical progresses must work so as to raise the productivity of factor V_2, labor and capital. However, more fundamentally expansion of output itself in resources to be put in both goods X and Y is sure to be desired.

So, here we must turn to the output of natural resources which we have considered as the factor of production.

Let's call such resource goods as goods N, industries producing them industry N, and consider the growth rates of supply and demand.

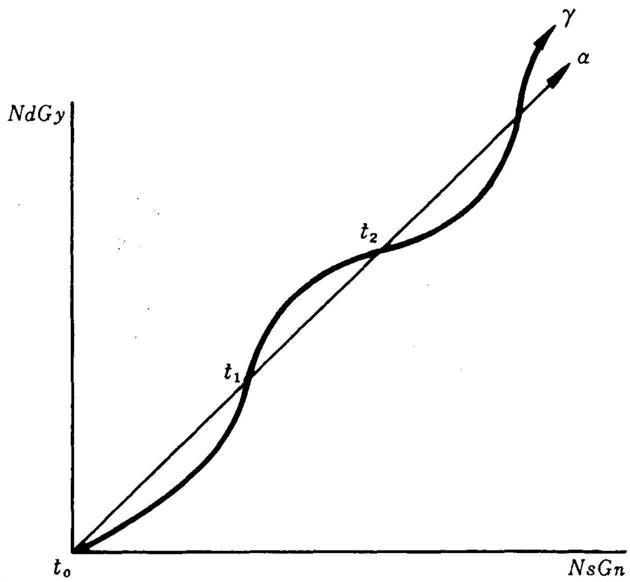
At least generically the equilibrium growth rate of goods N is formulated as $N_d \cdot G_y = N_S \cdot G_N$.

N_d denotes the output elasticity of demand, G_y the growth rate of national income, N_S the elasticity of resource supply, and G_N the expansion rate of space feasible as resources. Of course the left-hand side of the equation represents the growth rate of demand and the right-hand side that of supply. That the two sides equal means well-balanced growth of N.

Considering most simply, the supply-demand growth rate of goods N may be shown as **Figure 9.**

The line α in the diagram expresses a balanced-growth line, where $N_dG_y=N_SG_N$. It is usually anticipated that in the early stage of life cycle of N the feasible resource space is sufficient and so any necessary output is possible by input of labor and capital. Accordingly from t_0 to t_1 $N_dG_y<N_SG_N$. After t_1, however, the position becomes $N_dG_y>N_SG_N$ unless there is corresponding G_N. Probably this inclination will arise because some time lag is likely to exist between space ex-

Figure 9



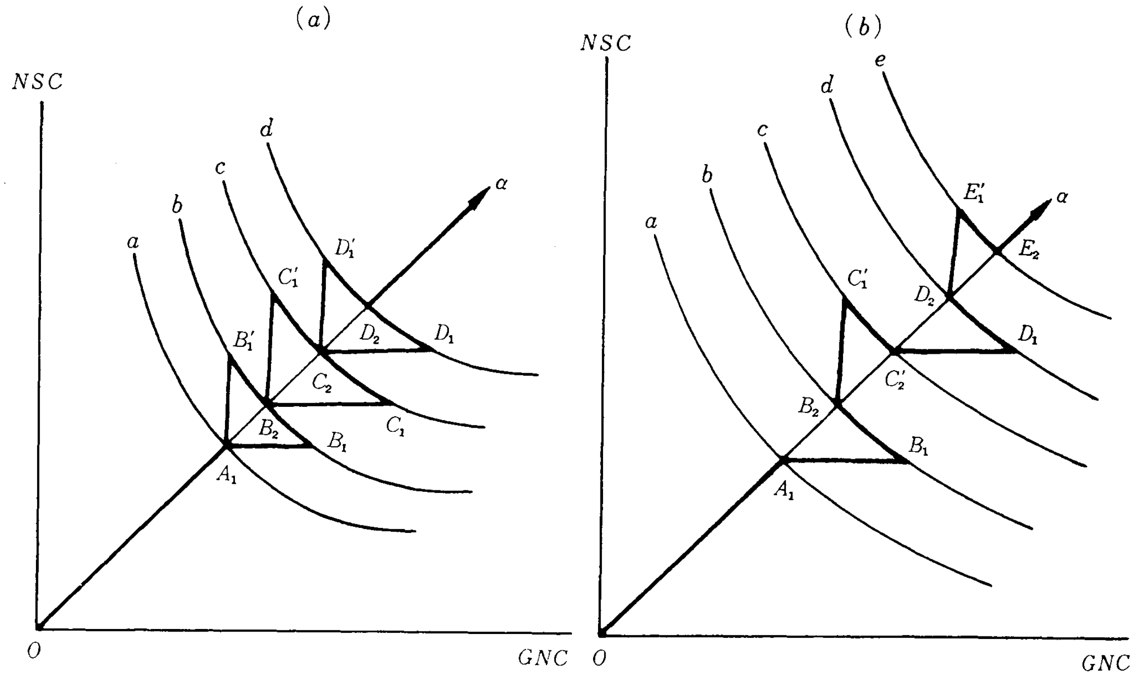
pansion and output increase. Yet, after t_2 again the growth rate of supply will surpass that of demand. For the effect of resource exploitation is supposed to appear there, as is discussed referring to the dual character of investment. Thus the actual rate of supply-demand growth is conceived to be the curve γ, cycles around the line α. This depends on the particular characters of N_S and G_N on the supply side. So let's examine the behavior of these in the below.

Firstly to observe the character of industry N, it comprises various industries with specific features. For example, N_1 extracts resources deposited in some specified places (oil, mineral ores, fishery), N_2 cultivates and harvests on specified fields, and N_3 obtains resources but conducts plantation for future cultivation (forestry). G_N in industry N_1 presupposes business activities for investigation, prospectation and acquisition of rights, while N_S those for extraction, transport and deeper exploitation. Similarly in industry N_2, G_N presupposes land cultivation, fertilizing, tillage and harvesting; in industry N_3, G_N presupposes investigation, woodland opening and plantation, and N_S forest-road construction, feeling and transport. In other words, industry N consists of two major activities. One is extraction from nature and another is expansion of the economic space of nature itself from which goods N are extracted. The former is conceived to administer N_S and the latter G_N.

Now, presupposing such activities of industry N, its expansion process may be viewed from two aspects of investment costs for extraction (*NSC*) and those for expnasion (*GNC*).

In Figure 10, taking the X-axis for *NSC* and the Y-axis for *GNC*, curves *a, b, c,*. . . . are drawn. They show production costs necessary to produce a certain volume of goods N on a certain amount of extraction investment as the function

Figure 10



of costs of feasible-space expansion. Of course the curves *a, b, c,*. . . .express that by incresaing *NSC* and *GNC* a larger volume of goods *N* can be produced.

In this situation, as rational behavior enterprises will intend to increase output while minimizing both *NSC* and *GNC*. In the diagram this is the point where the sum of both coordinate values becomes minimum. The direct line connecting such points on the curves is shown as α, along which enterprises will expand production.

However, in the case of resource industries it would be necessary to increase either *NSC* or *GNC* if output is to be expanded. If an increase in *GNC* is employed for the means, since N_S presupposes a given G_N, expansion takes a pattern of $A_1B_1B_2C_1$. . . .in Figure 10(*a*), with the output increasing as shown by the upward shifts of the curve, $a \rightarrow b \rightarrow c$. This is the case, for example, with enlargement of farm land, new-mine exploitation by investigation, or acquisition of new fishing ground. Contrastively if *NSC* is taken for the means, the pattern is $A_1B'_1B_2C'_1$. Examples for this are investment to get larger harvest from given acerage, deeper exploitation of existing mine, or opening of woodland by road construction.

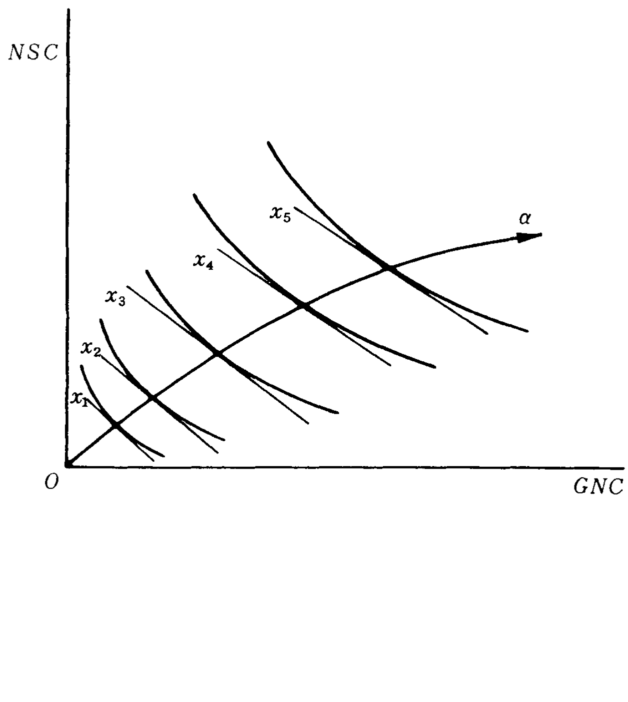
Actually, of course, a pattern of interchanging these two courses is conceivable like $A_1B_1B_2C'_1C_2D_1$. . . .as shown by Figure 10(b). Supposedly this depends on the particularities of resource industries each, that is, the degree of dependency of N_S on G_N. Especially G_N may be dominated by the physical conditions of the industry concerned. For instance, forestry is *NSC*-oriented, with deeper-forest felling making an essential condition to facilitate supply increases. However, there are life cycles even for forest resources and mines. Mines have limits of possible working. Ore contents decline with the advance of working, and hence prospecting is always carried in order to explore better mines. If so, the said *NSC*-oriented growth naturally has boundaries, and the *GNC*-oriented pattern must be employed in the long run. This inference may be further backed up by supposing a second condition to take account from the viewpoint of economics.

In the above we considered the line α to be the locus of the minimum-cost points of *NSC* and *GNC*. We will examine this anew by the conditions of factor costs. Let's formulate $N_S=f(L_1, K_1)$, $G_N=f(L_2, K_2)$, where L denotes labor and K capital. And we assume that $\frac{K_1}{L_1}<\frac{K_2}{L_2}$. If the prices of these factors are given on the markets, (representing wage rate by ω and capital reward rate by γ), $NSC=\omega L_1+\gamma K_1$ and $GNC=\omega L_2+\gamma K_2$. If, as is presupposed in the classic model, an increase in wages is larger than that in capital rewards, labor-intensive *NSC* will become dearer than *GNC*, and the ratio of costs will show slopes such as $x_1, x_2, x_3, \ldots$ in Figure 11. Then the line α—locus of the point of minimum sum of *NSC* and *GNC*—will bend rightward. This may enable us to infer that in industry N the incresae of output in itself takes the *GNC*-oriented pattern in the long run.

However, if technical progresses had occurred in N_S, possibly *NSC* would relatively decline and such right-downward bending of the line α would not be seen. Contrastively, in the case of technical progresses on the side of G_N the bend would be intensified. Thus the curve will naturally be influenced by the types of technical progresses, that is, *NSC*-saving, *GNC*-saving or *NSC*-*GNC*-saving.

As above, by observing the output of natural resource goods themselves, we can say about its growth rate as follows. (1) The growth rate is the product of

Figure 11



the rate of expansion of space feasible as resources and the rate of possible extraction from it; (2) these two rates depend respectively on the expansion investment cost and the extraction investment cost. Entrepreneurs wish to minimize these costs for increasing output but the long-run inclination is expansion-investment-oriented due to the character of resource industries; (3) technical progresses are seen for the two aspects, by whose types the orientation of expansion is affected.

On the other hand, what factors are conceivable that dynamically work on the growth rate of demand in resource industries?

As one of such factors changes in the method and use of resources can be mentioned. For example, as to wood recently a change from structural frames to material stuffs is seen, with the weight of the latter increasing. Again usage of oil has been diversified, with the shares in consumption greatly changing. These mean an appreciable change in the demand function.

The second is the birth of substitutive products, for example, expanded use of energy other than oil, of aluminum against copper, and of iron frame against timber. These must exert strong influences on the growth rate of demand through the elasticity of substitution.

The third is shifts of preference in the sorts of goods. This, while being a result of other numerous factors, causes disconformity with supplied goods and hence gaps between supply and demand. And it should be kept in mind that in the resource industry it takes appreciably long to adjust such gaps between demand-prefered goods and production-oriented goods. Unbalanced growth in the resource industry is being born from this, it may be said.

V. Conclusion

From the above theoretical analysis of abstract form models, we could obtain the following suggestions.

First, economic growth depends not only on labor and capital but also on the given existence of natural resources. The properties of heterogeneity and limitedness of the latter cause increases in real costs and physical constraints. Through this process, price increases in resources will induce possibilities of resource-saving technical progresses in manufacturing industries using them.

Second, under free trade the scale of trade is expanded by economic growth, with the self-sufficiency rate in the importer countries of resource-intensive goods declining. As their terms of trade becomes unfavorable by the scarcity-tendency of resources, self-sufficiency in these countries rise but the standard of welfare has to decline.

Third, these moves, however, depend on the output of the resource industry itself. The output can be regarded as the composite produce of two kinds of business activities, extraction and expansion. This depends on investment costs, which may be said more expansion-oriented. This substantially influences the growth rate of the resource industry, yet there is abundant room for technical progress whose orientation, whether *NSC*-saving or *GNC*-saving, administers the course of growth.

Fourth, since on the demand side there are changes in use, shifts to substitutive goods and turning of preference, it may not always be said that in the long run demand exceeds supply in the rate of growth. Rather conceivable are cyclical gaps born from time lag of growth between supply and demand.

Accordingly we can say about the resource problem that bottlenecks by the scarcity-tendency lie in economic growth, but on the other hand cyclical moves by the mechanism of price and technical progresses are suggested therein.