THE GOAL OF SUSTAINABLE DEVELOPMENT AND ENVIRONMENTAL KUZNETS CUEVES

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1. INTRODUCTION

What does sustainable development mean ? There are many definitions of sustainable development, but they are often incompatible with each other. At the risk of oversimplification, we can distinguish two broad ideological groups in environmentalism. One group pursues expansion of consumption for economic growth, and the other group aims to limit consumption for conservation of environment. The result to pull to opposite directiens from each other is no change. That is why we are not able to progress to sustainable development.

We need to find out the goal of sustainable development. To discuss the goal as a whole is beyond this paper. We advance an argument focusing on economic growth. Some people regard sustainable development as continuous economic growth. The other people argue steady - state economy is necessary for sustainable development. There are some people, moreover, who think reductions in the scale of economy are required for sustainable development. Which position is right ? Should we pursue eternal GDP growth or not ?

The purpose of this paper is to find out the goal of sustainable development with focusing to GDP growth. The most publicized definition of sustainability is that of the World Commission on Environment and Development (WCED) (the ' Brundtland Commission ', 1987). The Commission defined sustainable development as:' development that meets the needs of the present without compromising the ability of future generations to meet their own needs '(WCED, 1987 p. 43). Most people may agree with this definition. But it is not clear how to achieve this. Therefore, we will consider that what sustainable development means in terms of economic growth in this paper. Some conditions of sustainable development that emerges from this paper are as follows: 1. Abundant renewable resources. 2. Small estrangement between rich and poor countries. 3. Elastic resource price of the amount of resources.

This paper is organized in four sections. First of all we shed light on the arguments for and against ' limits to growth ' in order to find out the goal of sustainable development focusing on economic growth in chapter 2. This is the main purpose of this paper. But we

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cannot get a clear conclusion from these arguments. Therefore we discussthe arguments of weak and strong sustainability in order to consider the sustainability focusing on theoryin chapter 3. And we also discuss the arguments of environmental Kuznets curves in order to consider the sustainability focusing on empirical study in chapter 4. Then we analyze a dynamic growth model of a small country economy in order to find out the conditions of sustainable development in chapter 5.

2. PRO- GROWTH VERSUS ANTI- GROWTH

The features of the anti- growth approach are as follows: there are biophysical limits to the expansion of the economy if that expansion involves more waste being disposed of to a finite environment.

The term ‘ limits to growth ’ itself was the title of a book by Donella and Dennis Meadows and a team from the Massachusetts Institute of Technology (MIT). For the Meadows team the limits were ecological limits, and they applied to economic growth, understood as growth in production as measured by GNP, which they assumed implied a similar increase in the consumption of resources. They concluded: ‘ The most probable result (of reaching the limits to growth) will be a rather sudden and uncontrollable decline in both population and industrial capacity ’ (Meadows et al. 1974).

While the ‘ limits to growth ’ thesis had the general public response, economists and other scientists were quick to seek to discredit it. Two of the most comprehensive rebuttals came from a team at Sussex University ’s Science Policy Research Unit (Cole et al. 1973), and from William Nordhaus (1973). They criticized the relationships in Meadows ’ model, the assumptions on which the model was based and the emphasis on purely physical parameters.

On the basis of their critique, Cole et al. Reran Meadows ’ model with different assumptions and produced quite different results. This was also not a priori surprising because the key assumption they replaced was that of absolute limits by introducing ongoing exponential increases in available resources (through discovery and recycling) and the ability to control pollution.

Nordhaus (1973) also reran the model with different assumptions, re - specifying the model ’s population behaviour and its savings assumption, and introducing technological change and substitution possibilities. All the changes in assumptions dramatically changed the behaviour of the model, with the introduction of technical change and sustainability having the greatest effect, either significantly postponing the model ’s ‘ overshoot and collapse ’ trajectory or converting it into one of continually increasing consumption.

Lecomber (1975) admirably expresses the difference between resource optimists, such as Nordhaus and Cole et al. and pessimists such as the Meadows ' team. He identified the three key effects that can reduce depletion or pollution: changes in composition of output; substitution between factor inputs; and technical progress (more efficient use of the same input). If these three effects add up to a shift away from the limiting resource or pollutant equal to or greater than the rate of growth, then the limits to growth are put back indefinitely. Lecomber (1975) also pointed as follows:

> Everything hinges on the rate of technological progress and possibilities of substitution. This is perhaps the main issue that separates resource optimists and resource pessimists. The optimist believes in the power of human inventiveness to solve whatever problems are thrown in its way, as apparently it has done in the past. The pessimist questions the success of these past technological solutions and fears that future problems may be more intractable.

Whatever the potential of technological change, there are certain physical constraints, defined by the laws of thermodynamics, that cannot be circumvented. The second Law - that all activity and transformation of energy or materials leads to an increase of entropy - has been most extensively related to economics by Georgescu - Roegen (1971)

In this analysis it is the increase of entropy that is the ultimate limit to growth. Economic activity increases entropy by depleting resources and producing wastes. Entropy on earth can only be decreased by importing low entropy resources (solar energy) from outside it. Growth in physical production and throughput that is not based on solar energy must increase entropy and make environmental problems worse, implying an eventual limit to such growth. Therefore, GNP can free itself from these limits only to the extent that it ' decouples ' itself from growth in physical production. As will be seen later section, such decoupling has occurred to some extent, but the entropy law decrees that it can never be complete. Optimists believe that the decoupling can be substantial and continuous but pessimists are more skeptical. This argument can be related to the argument of ' Environmental Kuznets Curves '. The existence of environmental Kuznets Curves is crucial for this argument. Therefore, we will see the argument of environmental Kuznets Curves at next chapter.

There are another arguments of limits to growth. K. W. Kapp who made the first exploration of the social costs of the growth process (Kapp 1950), but it was Mishan (1967, 1977) who first brought these costs to widespread public notice. Mishan (1977) said that ' the upward movement in the indicators of social disintegration - divorce, suicide, delinquency, petty theft, drug taking, sexual deviance, crime and violence - has never faltered over the last two decades '. It is Mishan 's thesis that these and other ill effects are the results of economic growth and far outweigh its benefits.

The ecologists' concern was with the physical limits to economic growth. Mishan's focus is on the limits to social welfare that can be derived from growth. Hirsch adds to the picture by postulating social limits to growth. Hirsch's social limits derive from two causes: the increasing importance of positional goods; and the breakdown of individual morality in an affluent, growing economy. The positional economy 'relates to all aspects of goods, services, work positions, and other social relationships that are either (1) scarce in some absolute or socially imposed sense or (2) subject to congestion or crowding through more extensive use' (Hirsch 1976). As incomes rise, the demand for positional goods increases; with fixed or very inelastic supply, the goods are either rationed through price (e.g. desirable resort properties) or criteria of eligibility (e.g. more stringent examinations) or their quality is degraded through overcrowding (e.g. roads). The effect is either to reduce growth, or the welfare to be derived from it or both.

The 1970s growth in environmentalism was closely associated with 'anti-growth'. But the 1970s' limits to growth critiques, both physical and social, failed to dent the social consensus in favor of economic growth, so that by the time the Brundtl and Commission produced its report, Our Common Future (WCED 1987), on environment and development, the emphasis was placed on a perceived complementarity between growth and environment. In her introduction to the report, Mrs Brundtland calls for 'a new era of economic growth - growth that is forceful and at the same time socially and environmentally sustainable' (WCED 1987: xii).

This bullish attitude was justified by statistics, which showed that over the period 1972-86 the relationship between energy use and economic growth in industrial countries had undergone a significant change from the broadly proportional relation that had pertained before. In the US, energy intensity (the amount of energy used per unit of GDP) from 1973-86 diminished by 25 per cent. Over the OECD as a whole, it fell by 20 per cent from 1973-85. I the same period for countries belonging to the International Energy Agency, GDP grew by nearly 32 per cent, but energy use only by 5 per cent (WRI 1990: 146). A 'decoupling' of economic growth from energy consumption was proclaimed.

In an even more optimistic twist to this debate, Bernstam (1991) postulates that industrializati on under free market conditions exhibits a characteristic relationship between output and the environment, as follows. In the early days there is a negative trade-off at the expense of the environment. This effect diminishes as industrialization proceeds and, at a certain historical moment, there is a positive relationship between the two. At this point 'economic growth can reduce pollution if it increases the productivity of resources (that is, reduces wastes) faster than both resource output and population growth'.

This assertion remains at the level of pure conjecture. In fact, it is flatly contradicted by trends in energy use since 1986. US energy intensity actually increased (that is, more energy was used per unit of GDP) in 1987 and 1988, as did that of several European countries (WRI 1990: 146). The overall conclusion of which is that there is no evidence that, over a prolonged period, Bernstam's condition for growth to reduce overall environmental impacts is being met.

Beckerman (1992), arguing for economic growth in developing countries, adopts the same line of argument as Bernstam (1991) with an intriguing difference. Beckerman's thesis was that continuing economic growth in industrial countries would reduce their contribution to global pollution, which would go some way towards compensating for the inevitable rise in pollution from growth in developing countries. Beckerman contends that it is developing countries that need economic growth to improve their environments, at least in important areas such as access to drinking water, sanitation and air quality. He concludes: 'In the longer run, the surest way to improve your environment is to become rich' (Beckerman 1992: 491).

A comparison between the attitudes of the 1970s and the 1990s shows that the resource pessimists' conclusions are essentially unchanged, but, with the exception of the Bernstam / Beckerman views, there has been a significant shift in the mainstream resource optimists' position since the 1970s. Now the broad conclusion of the mainstream optimists is that environmental problems are real and threatening and that to be reconciled with continuing economic expansion active policy will be required.

On the other hand, anti - growth view has resurfaced in recent years. Herman Daly is perhaps one of the best known exponents of the view that there are biophysical limits and that economic systems have to be reorganized and managed so as to reflect those limits (Daly 1991). He observes that macroeconomics lacks a concept of 'optimal scale', in contrast to microeconomics, which spends significant amounts of time analyzing the optimal size of a firm. Macroeconomic systems are a sub - component of a much large set of ecosystems. By 'scale' Daly means the volume of resources per capita multiplied by the size of the population.

Barbier (1987) has suggested that sustainable development should be viewed as an interaction between three systems, the biological, economic and social systems. 'The general objective of sustainable economic development, then, is to maximize the goals across all these systems through an adaptive process of trade - offs' (ibid.: 104). The multi - dimensionality of objectives embraced by sustainable development has resulted in it coming to mean different things to different people. By 1989 Pearce et al. were able to cite a 'gallery of definitions' (Pearce et al. 1989: 173 - 85), which by 1993 could have been much extended. Such diversity of meaning clearly militates against clarity of discourse.

The weaknesses in conceptualization have added to the confusion concerning the growth / sustainability relationship. The debate of limits to growth has been left hanging in the air. We haven't had the answer even for whether there are limits to growth or not. One of the most important judger for this question is Environmental Kuznets Curves. If 'decoupling' between economic growth and environment degradation is possible, we don't need anti - growth.

Before seeing the Environmental Kuznets Curves, we need to see the argument of basic theory of sustainability in order to know the background of the arguments of the Environmental Kuznets Curves. Therefore we will see the arguments of weak and strong sustainability at next chapter. Then, we will see arguments of Environmental Kuznets Curves.

3. WEAK VERSUS STRONG SUSTAINABILITY

We argued about pro - growth and anti - growth as two main view of sustainable development in chapter 2. The concept of sustainable development can also be divided in two aspects in another way. In this section, we will argue aboutweak and strong sustainability before the Environmental Kuznets Curves. The arguments of this section are based on'Blue print' (Pearce et al. 2000 : 23 - 29) and 'Economic Growth and environmental Sustainability'(Ekins. 2000).

The main difference of 'Weak' and 'Strong' sustainability is whether natural capital has a unique or essential role in sustaining human welfare, and thus whether special compensation rules are required to ensure that future generations are not made worse off by natural capital depletion today.

According to the weak sustainability view, there is essentially no inherent difference between natural and other form of capital, and hence the same optimal depletion rules ought to apply to both. As long as the natural capital that is being depleted is replaced with even more valuable physical and human capital, then the value of the aggregate stock - comprising human, physical and the remaining natural capital - is increasing over time. Maintaining and enhancing the total stock of all capital alone is sufficient to attain sustainable development.

In contrast, proponents of the strong sustainability view argue that physical or human capital cannot substitute for all the environmental resources comprising the natural capital stock or all of the ecological services performed by nature. Essentially, this view questions whether, on the one hand, human and physical capital, and on the other, natural capital, effectively comprise a single homogeneous total capital stock. Uncertainty over many environmental values, in particular the value that future generations may place on increasingly scarce natural resources and ecological services, further limits our ability to determine whether we can adequately compensate future generations for irreversible losses in essential natural capital today. Thus the strong sustainability view suggests that environmental resources and ecological services that are essential for human welfare and cannot be easily substituted by human and physical capital should be protected and not depleted. Maintaining or increasing the value of the total capital stock over time in turn requires keeping the non - substitutable and essential components of natural capital constant over time.

There is then the issue as to whether it is the total stock of capital that must be maintained, with substitution allowed between various parts of it, or whether certain components of capital, particularly natural capital, are non - substitutable, i. e. they contribute to welfare in a unique way that cannot be replicated by another capital component. Turner (1993: 9 - 15) identifies four different kinds of sustainability, ranging from very weak, which assumes complete substitutability, to very strong, which assumes no substitutability so that all natural capital must be conserved. The assumption of the former is implicit in the so - called 'Hartwick rule' (Hartwick 1977), namely that, provided that the resource rents from the exploitation of exhaustible resources are invested in manufactured capital, per capita consumption can remain constant indefinitely over time. Very strong sustainability has been called 'absurdly strong sustainability' (Daly 1995 : 49) in order to dismiss it from practical consideration. Turner's more interesting intermediate categories are:

- Weak environmental sustainability, which derives from a perception that welfare is not normally dependent on specific form of capital and can be maintained by substituting manufactured for natural capital, though with exceptions.
- Strong sustainability, which derivers from a different perception that substitutability of manufactured for natural capital is seriously limited by such environmental characteristics as irreversibility, uncertainty and theexistence of 'critical' components of natural capital, which make a unique contribution to welfare. An even greater importance is placed on natural capital by those who regard it in many instances as a complement to man - made capital (Daly 1992:27)

The point at issue is which perception most validly describes reality. Resolving this point should be an empirical rather than a theoretical or ideological matter. The assumption underlying weak sustainability is that there is no essential difference between different forms of capital, or between the kinds of welfare, which they generate. On the other hand, the strong sustainability keeps natural capital distinct from other kinds of capital, it can examine natural capital's particular contribution to welfare, distinguishing between its contribution to production (through resource - provision and waste - absorption) and its services that generate welfare directly. The examination may reveal that in some cases the welfare derived from natural capital is fully commensurable with other welfare from production and can be expressed in monetary form, so that in these cases substitutability with other forms of productive capital exists, and the weak sustainability condition of a non-declining aggregate capital stock I sufficient to maintain welfare. In other case the outcome of the examination may be different. The important point is that, starting from a strong sustainability assumption of non-substitutability in general, it is possible to shift to weak sustainability position where that is shown to be appropriate. But starting from a weak sustainability assumption permits no such insights to enable exceptions to be identified. Therefore strong sustainability seems to be adequate as a priori position.

There are other theoretical reasons for choosing the strong sustainability assumption. Victor (1991: 210-11) notes that there is recognition in economics going back to Marshal that manufactured capital is fundamentally different from environmental resources. The former is human-made and reproducible in the quantities desired, the latter is the ‘ free gift of nature ’ and, in many categories, is in fixed or limited supply. The destruction of manufactured capital is very rarely irreversible (this would only occur if the human capital, or knowledge, that created the manufactured capital had also been lost), but irreversibility, with such effects as species extinction, climate change, or even the combustion of fossil fuels, is common in the consumption of natural capital. Moreover, to the extent that manufactured capital requires natural capital for its production, it can never be a complete substitute for resources.

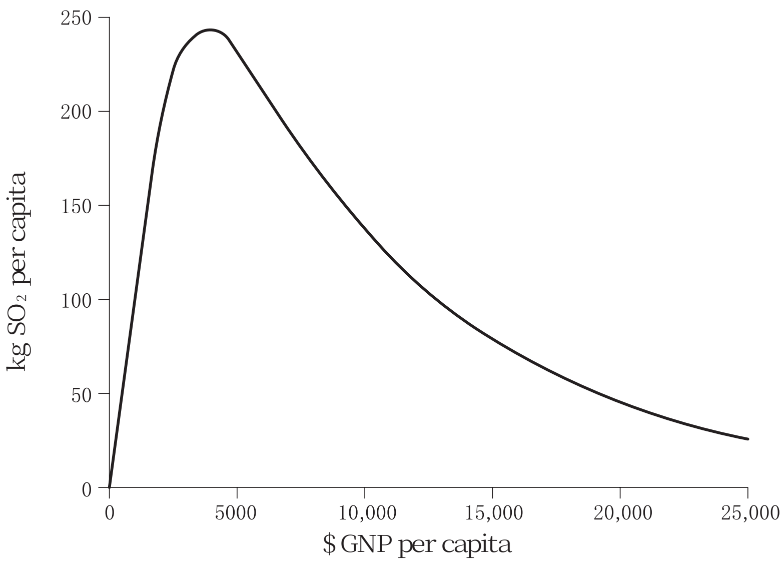
Victor et al. (1995: 206) identify the elements of natural capital that are essential for life as we know it as water, air, minerals, energy, space and genetic materials, to which might be added the stratospheric ozone layer and the relationships and interactions between these elements that sustain ecosystems and the biosphere. Some substitution of these essential elements by manufactured and human capital can be imagined, but their whole substitutability, as assumed by weak sustainability, appears improbable, certainly with present knowledge and technologies. In fact, if the process of industrialisation is viewed as the application of human, social and manufactured capital to natural capital to transform it into more human and manufactured capital, then it is possible to view current environmental problems as evidence that such substitutability is not complete. If our current development is unsustainable, it is because it is depleting some critical, non-substitutable components of the capital base on which it depends. ‘ Critical natural capital ’ may then be defined as natural capital which is responsible for important environmental functions and which cannot be substituted in the provision of these functions by manufactured capital.

The difference between weak and strong sustainability is important to the argument about the compatibility of sustainability and GDP growth. In general, it may be said that production for GDP growth is generated by transforming energy and materials from the natural environment into human - made goods and services. Fewer environmental goods can be permanently transformed into human - made capital under strong sustainability than under the weak version. Therefore strong sustainability principle would make the generation of GDP more difficult. The fewer the substitution possibilities allowed, the more stringent the conditions for the compatibility of sustainability and GDP growth.

Recent extensions to the economic theory of sustainable development have not so much resolved this debate as sharpened its focus. We need to see arguments of empirical matter for coming close to the answer. Therefore, we will see arguments of environmental Kuznets curves at next chapter.

4. ENVIRONMENTAL KUZNETS CURVES

There has been a lot of research in the recent years deriving econometric relationship between income and various indicators of environmental quality. A wide variety of results has been obtained, including for some environmental indicators an inverse U - relationship, where environmental degradation is seen to increase at low incomes, reach a peak and then improve as income increases beyond this threshold. This pattern is described as an environmental Kuznets curve (EKC), following the observation by Kuznets (1955) that it appeared to describe the relationship between the level of income and income inequality. Figure 1 shows a typical EKC estimated for sulphur dioxide (SO_2). One important interpretation of such EKC relationship is that general economic development will take care of the environment automatically.



Source: Pearce and Barbier, 2000

Figure 1. An Environmental Kuznets Curve for Sulphur Dioxide

The above curve is the environmental Kuznets curve for SO_2 estimated across rich and poor countries of the world by Panayotou (1995). The peak or turning point level of per capita income where environmental degradation starts to fall is about US＄5,000.

The observation of the EKC for some environmental indicators has led to variety of conclusions from the researchers and others about the overall growth - environment relationship, such as:

> We find that while increases in GDP may be associated with worsening environmental conditions in very poor countries, air and water quality appears to benefit from economic growth once some critical level of income has been reached.
>
> (Grossman and Krueger 1994: 18 - 19)

> The evidence suggests that it is possible to‘ grow out ’of some environmental problems.
>
> (Shafik and Bandyopadhyay 1992: 23)

> We have found, through an examination of air - quality measures in a cross - section o countries, that economic growth tend to alleviate pollution problems once a country 's per capita income reaches about ＄4,000 to ＄5,000 US dollars.
>
> (Grossman and Krueger 1991: 35 - 6)

> Environmental degradation overall (combined resource depletion and pollution) is worse at levels of income per capita under ＄1,000. Between ＄1,000 and ＄3,000, both the economy and environmental degradation undergo dramatic structural change from rural to urban, from agricultural to industrial. A second structural transformation begins to take place as countries surpass a per capita income of ＄10,000 and begin to shift from energy intensive heavy industry into services and information - technoligy intensive industry.
>
> (Panayotou 1993: 14)

> The inverted U - shape is consistent with a scenario in which industrial development initially leads to greater raw emissions of these pollutants, but net emissions eventually decline as the increase in income environmental quality… (This literature) raises the tantalizing possibility that instead of there being a trade - off between greenhouse gases and economic growth, faster growth could serve as part of the solution to the worldwide emissions dilemma.
>
> (Holtz - Eakin and Selden 1992: 3)

> Growth promoting liberalization of trade will often lead to improved environmental standards.
>
> (Radetzki 1992: 134)

These are strong conclusions. They create the impression that economic growth and the environment are not only in conflict (the former is necessary to improve the latter). This conclusion turns the ' limits to growth ' argument as follows. Instead of the environment setting limits to growth, these conclusions suggest that growth is a requirement of environmental improvement.

Panayotou (1993) gives the most unequivocal expression to the conclusions that can be drawn from a general acceptance of an EKC relationship between growth and environmental quality:

> It suggests that as the development process pick up, when a certain level of income per capita is reached, economic growth turns from an enemy of the environment into a friend … Economic growth appears to be a powerful way for improving environmental quality in developing countries … If economic growth is good for the environment then policies that stimulate growth such as trade liberalization, economic restructuring and price reform ought also to be good for the environment. This in turn would tend to suggest that the environment needs no particular attention, either in term of domestic environmental policy or international pressure or assistance; resources can best be focused on achieving rapid economic growth to move quickly through the environmentally unfavourable stage of development to the environmentally favourable range of the Kuznets curve.
>
> (Panayotou 1993: 14)

Taken to extremes, we do not have to regard the environment as anything special. As people get richer they will increase their demand for the environment and improve it, initially with public health legislation, then clean air, then conservation generally. From this view, we don 't need anti - growth. All we need for environment is to pursue the economic growth.

But it is still not clear that we understand fully these critical relationships. For example, many of the original explanations of the EKC hypothesis focused on changes in the composition of goods and services due to structural shifts in the economy, the efficiency of resource use, the composition of inputs and technological innovation. However, it has increasingly been recognized that the effects of such changes on environment - income link are not exogenous processes - determined by factors outside the economy - but are influenced by policy choices (Panayotou 1995 ; Stern et al 1996 ;

World Bank 1992). Similarly, previous conjecture that the environmental quality is simply a luxury good - that the demand for improved environmental quality increases more than proportionately with income - is proving difficult to substantiate (McConnell 1997).

In addition, it has been suggested that EKC relationships may hold only for certain type of environmental damage, such as pollutants with more short - term and local impacts rather than those with more global and long - term impacts(Arrow et al 1995; Cole et al 1997; Selden and Song 1994).

Arrow et al (1995) argued that there is nothing that conclusive evidence of an EKC relationship, it applies only to a few pollutants, thus making it difficult to use this evidence to image more generally about growth - environment linkages. Still others have pointed out that, even for those pollutants displaying EKC characteristics, aggregate global emissions are projected to rise over time, demonstrating that the existence of an EKC relationship for such pollutants does not necessarily imply that, at the global level, any associated environmental damage is likely to disappear with economic growth. Unfortunately, for at least two major global environmental problems - SO_2 emissions and deforestation - existing policy interventions do not appear to be enough, as projections of estimated EKC relationships for SO_2 and forest cover confirm that these problems will continue to worsen on a global scale (Selden and Song 1994; Stern et al 1996). Ekins (2000: 211) pointed as follows:

> In fact, insofar as the EKC studies permit any conclusions at all, they provide evidence of unsustainable development rather than the reverse. Sustainable development requires the modification of the historical environment - income relationship, as much where there is limited evidence of an inverted - U relationship between income and environmental quality as where there is a clear positive relationship between these variables. There is no evidence that such a modification will emerge endogenously from the growth process. It seems likely to require determined environmental policy.

But the observation of Vincent (1997) from his analysis of Malaysia also pointed as follows:

> The lack of evidence of EKCs in Malaysia does not prove that EKCs do not exist anywhere. It does indicate, however, that policy makers in developing countries should not assume that economic growth will automatically solve air and water pollution problems. '

Again, we have not got the clear answer to the arguments about EKC. But we have got a conclusion that environmental policy plays an important role in sustainable development. Therefore, we consider next about what kind of policy we need for sustainable development with simple small country model at next chapter.

5. CAPITAL ACCUMULATIONS IN A SMALL OPEN ECONOMY

In the last chapter, we concluded that some environmental policies are required for sustainable development. Therefore, we will consider the policies we need for sustainable development with simple dynamic small economy model in this chapter. In this model we assume that natural resources are essential to manufactured production. The purpose of this model is to analyze the conditions for sustainable development in the small country within the extended framework of Krugman (1981) by adding renewable resource as the factor of manufacturing production. The Krugman model portrays a two - region world in which the industrial sectors of regions grow through the accumulation of capital. There is a crucial assumption. The assumption is external economies in the industrial sector. The Krugman model shows that ' uneven development ' is a necessary outcome in such a model: an initial discrepancy in capital - labor ratios between the two regions will cumulate over time, leading to the division of the world into a capital - rich, industrial region and capital - poor, agricultural region.

The World Commission on Environment and Development (WCED) (the ' Brundtland Commission ', 1987, p. 43) stated that both intergenerational equity and intra - generational equity concerns must be met before any society can attain the goal of sustainability. And Turner et al (1993: 15) pointed as follows:

> Basically, simple economic models have ignored the economy - environment interrelationships altogether. This, of course, is physically impossible and the implications of how an economy does in fact sustain itself over time lies at the core of environmental economic thought. In reality the opposite is the case. The economy is an open and circular system, which is only able to function because of the support of its ecological foundations. A working economy must extract, process and discard large amounts of physical materials. This means that the economy is subject to physical constraints.

We need to consider the equity and natural resource for sustainable development in economic models. Therefore, we also analyze possibility of even development of the world as well as sustainability of resources.

5. 1. THE MODEL

We consider a small country economy in which the industrial sector grows through the accumulation of capital. There are two crucial assumptions. One is external economies in the industrial sector. Therefore a small ‘ head start ’ for one region will cumulate over time, with exports of manufactures from the leading region crowding out the industrial sector of the lagging region. Second is essentialness of renewable resource for manufactured production. In this model, renewable resource plays crucial role. It is the source of manufactured production and it restrict eternal growth.

We assume that the small country has a labor force L and that these labor force does not grow over time. Thus we have

(1) $L_S=\bar{L}$.

Each country in the world is able to produce two goods, a manufactured good M and an agricultural product A, and to trade at zero transportation cost. There will thus be a single world price of manufactured goods in terms of agricultural products, P_M. Agricultural products are produced by labor alone; we will choose units so that one unit of labor produces one unit of agricultural goods.

The growth sector is manufacturing. Manufacturing requires capital K, labor L and renewable resource R. We assume that, from the point of view of an individual firm, the unit capital, labor and renewable resource requirements are fixed. In the aggregate, however, unit capital, labor and renewable resource requirements are not constants ; instead, in each region they are decreasing functions of the region s aggregate capital stock. Letting c, v and r are the capital, labor and renewable resource requirements for unit manufacturing production, respectively, we have

(2) $c_S=c(K_S), v_S=v(K_S), r_S=r(K_S)$

Where K_S is an amount of capital accumulations at the small country and c , v , r < 0 by external economies. Therefore, when the country produces M units of manufacturing good, then total requirements of capital, labor and renewable resources with respect to output are given by the following forms: $K_S=c_SM_S$, $L_S=v_SM_S$ and $R_S=r_SM_S$. However, we assume that the absolute value of the elasticity of unit input requirements with respect to output is less than one, so that total input requirements rise as ma nufacturing output rises.

Then, the output of manufactured good is defined as follows:

(3) $M_S=Min\left[\frac{K_S}{c(K_S)}, \frac{\bar{L}}{v(K_S)}, \frac{R_S}{r(K_S)}\right]$

At the initial point, we assume that labor force and renewable resource for manufacturing are abundant compare with capital (we are imaging this small country as a developing country). Given the relationships (2), then, together with full employment of factors, we can determine the pattern of output. The output of manufactured goods depends on the capital stock:

(4) $M_S = \frac{K_S}{c(K_S)}$

Given the output of manufactured goods, then, total requirements of labor and renewable resource with respect to output are given by the following forms : $v_S M_S$ a nd $r_S M_S$. Output of agricultural goods can then be determined from the agricultural secto r s role as a residual claimant on labor:

(5) $A_S = \overline{L} - v_S M_S$

There are two upper limits of capital accumulations: K_{MAXL} and K_{MAXR}. The K_{MAXL} is the amount of capital, which comes when the country is completely specialized in manufacturing and no more labor can be drawn out of agriculture. K_{MAXR} is the amount of capital, which comes when the input of renewable resources reaches the upper limit R_{max} and no more resources can be gathered. We can define K_{MAXL}, K_{MAXR} as follows:

(6) $\frac{v(K_{MAXL}) \cdot K_{MAXL}}{c(K_{MAXL})} = \overline{L}$, $\frac{r(K_{MAXR}) \cdot K_{MAER}}{c(K_{MAXR})} = R_{MAX}$

Next, we define the nature of the renewable resources. The stock of renewable resources will be decreased by input to industrial production and will increase by reproduction of them selves. We assume that reproduction of resources takes the form of logistic function according to basic renewable resources management models, and it is used only for industrial production. Thus, we can describe the change of renewable resources 'stock as

(7) $\dot{R}_S = aR_S(1 - \frac{R_S}{R_{MAX}}) - r_S M_S$ (a, R_{MAX}:positive constant)

Consider next the distribution of income. There are two cases: the case in which at least some labor is used in agricultural production, and the case of complete specialization in manufacturing. If some labor is used in agriculture, this ties down the wage rate, which is 1 in terms of agricultural goods. Using the world price of manufactured good P_M and the cost of gathering renewable resource C_R, then we can describe the profit of the smal country, π as follows:

(8) $\pi = P_M M_S - L_S - C_R^S R_S$

And we also have profit rate ρ_S as follows:

$$(9) \quad \rho_S \equiv \frac{\pi}{K_S} = \frac{P_M - v_S - r_S C_R^S}{c_S}$$

We assume that the input cost of renewable resources C_R depends on the amount of renewable resources, and it is a decreasing function of the amount of renewable resources.

$$(10) \quad C_R^S = C(R_S), C'(R_S) < 0$$

Since c and v are functions of the capital stocks and C_R is a function of the amount of renewable resources, therefore equations (9) and (10) could be combined into the reduced form given by equation (11)

$$(11) \quad \rho_S = \rho(P_M, K_S, R_S)$$

where $\partial \rho / \partial P_M > 0$, $\partial \rho / \partial K > 0$ and $\partial \rho / \partial R > 0$. The first expression means that a rise in manufactured good price causes increase the small countries profit rate. The second expression is caused by increasing returns to scale in manufacturing. The third expression means that an increase of resources in the country causes increase the small countries profit rate.

We assume this country is small enough not to have an effect on world manufactured goods price. Therefore P_M is given for the small country. But the world manufactured goods price could be affected by world capital stock, K_W. P_M is decreasing in the world capital stock.

$$(12) \quad P_M = P_M(K_W), P_M'(K_W) < 0$$

For the sake of easy algebra, we assume that all profits and only profits are saved. The savings assumption means that, if there is no international investment, the rate of growth of the capital stock in this country will just equal the rate of profit. And we also assume that capital stock depreciates with constant rate δ. Therefore the rate of change of capital stock will take a form as follows,

$$(13) \quad \frac{\dot{K}_S}{K_S} = Max[0, \rho(K_S, R_S)] - \delta$$

From equations (2), (9), (11) and (12), we could get characters of equation (13) as follows:

$$(14) \quad \frac{\partial \rho_S}{\partial K_S} > 0, \quad \frac{\partial \rho_S}{\partial K_W} < 0, \quad \frac{\partial \rho_S}{\partial R_S} = \frac{\partial \rho}{\partial C_R^S} \cdot \frac{\partial C_R^S}{\partial R_S} > 0.$$

The rate of change of capital stock in the small country is increasing in the own capi tal stock and resources, and decreasing in the world capital stock.

We have now set out a simple dynamic model for capital accumulation in the small country. The next step is to trace out and interpret the path of the small country economy over time.

5. 2. DYNAMICS OF THE SMALL COUNTRY

The equilibrium of this model is given by the point that $\dot{K}_S = 0$, $\dot{R}_S = 0$. Given the as sumptions in the last section, $\dot{K}_S = 0$ curve has a downward sloping at R_S - K_S plane.

(15) $$\frac{dK_S}{dR_S} = -\frac{\partial \rho_S / \partial R_S}{\partial \rho_S / \partial K_S} < 0$$

From the equation (8), the $\dot{R}_S = 0$ curve takes a form as follows

(16) $$K_S = \frac{c_S}{r_S}\{aR_S(1 - \frac{R_S}{R_{MAX}})\}$$

In order to simplify an analysis, we assume the change of inputs requirements as follows

(17) $$c_S : v_S : r_S = 1 : \alpha_0 : \beta_0 \qquad (\alpha_0,\ \beta_0 : \text{constant}).$$

Now, we have a figure (Figure 1) that illustrates the essential point of this dynamic growth model, and that shows us the level of capital accumulation and amount of renewa ble resources in this small country.

Figure 2:
The curve of accumulation zero ($\dot{K}_S = 0$) and the curve of resource change zero ($\dot{R}_S = 0$)

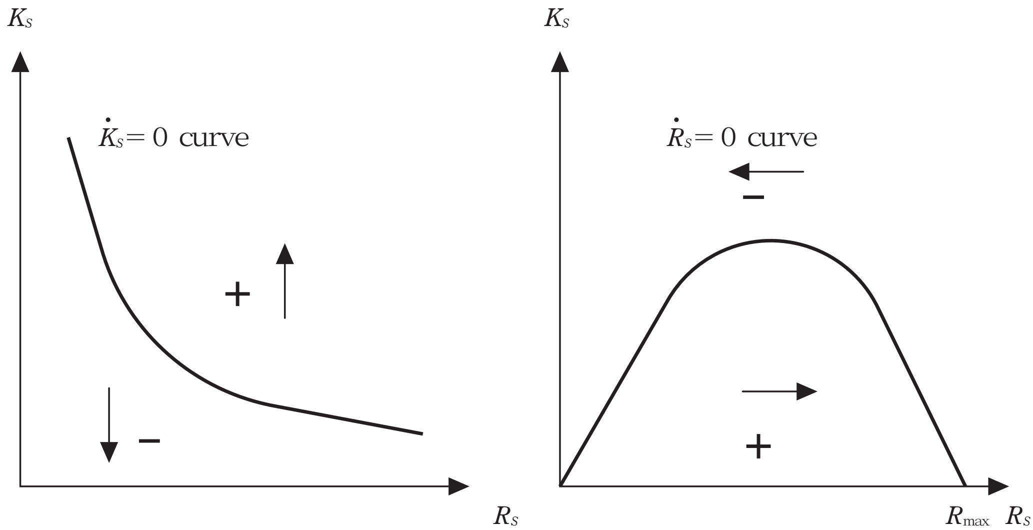


Figure 2 illustrates the essential point of the dynamic small country model. The $\dot{K}_S = 0$ curve indicates combinations of R_S and K_S for which the change of capital stock is zero. If the point, which represents a state of capital and resources in the small country, is upper from the $\dot{K}_S = 0$ curve, then $\dot{K}_S$ will be positive and capital will be accumulate, then the point will move to upward. If the point, which represents a state of capital and resources, is below from the $\dot{K}_S = 0$ curve, then capital will be declined by depreciation, the point will move to downward.

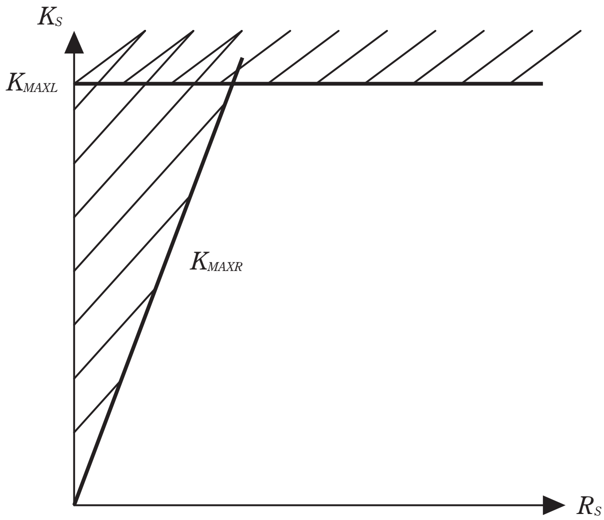
The $\dot{R}_S = 0$ curve indicates combinations of R_S and K_S for which the change of renewable resources is zero. If the point, which represents a state of capital and resources in the small country, is upper from the $\dot{R}_S = 0$ curve, then $\dot{R}_S$ will be negative and the amount of resources will decrease, then the point will move to leftward. If the point, which represents a state of capital and resources in the small country, is below from the $\dot{R}_S = 0$ curve, then $\dot{R}_S$ will be positive and the amount of resources will increase, then the point will move to rightward.

Next we consider two restrictions; labor restriction and resource restriction. From equation (6), we could get K_{MAXL} curve and K_{MAXR} curve, which represent two kinds of upper limits of capital accumulations.

$$(18) \quad K_{MAXL} = \frac{c_S}{v_S}\bar{L}, \; K_{MAXR} = \frac{c_S}{v_S} R_S$$

Figure 3 shows two restrictions. Capital cannot be accumulated over these lines. That is the point, which represents a state of capital and resources in the small country, could never go into the shaded area in the graph.

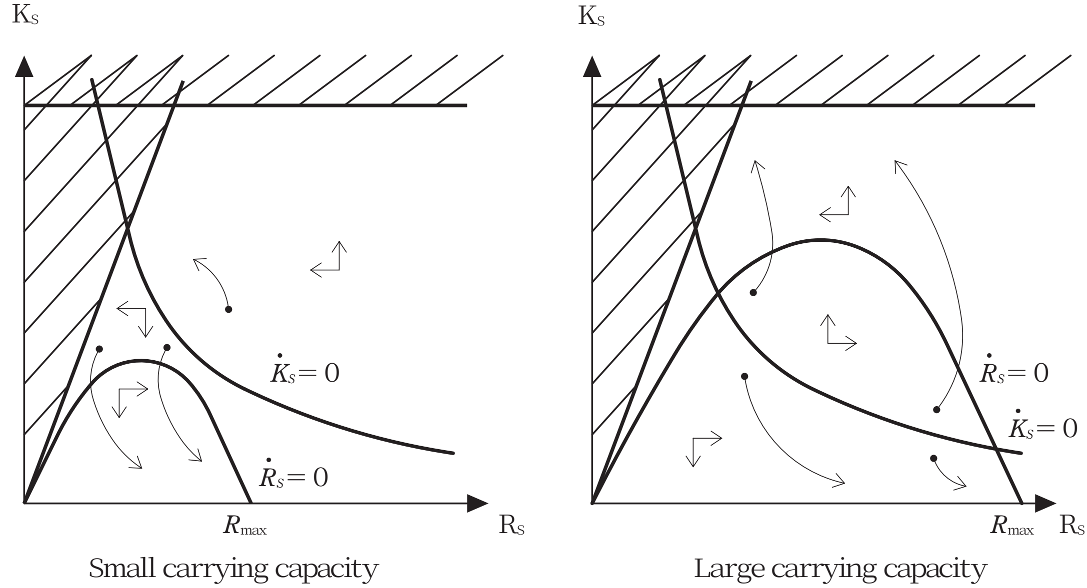
Figure 3：Labor restriction and resource restriction.



Next we consider the conditions for taking off to economic growth of this small country. We analyze the dynamic process of capital accumulation and renewable resource change in this country. First, we consider a case of no renewable resource trade. There are three key effects for growth：carrying capacity, world capital stock and cost elasticity to resource stock.

First, we consider the effect of carrying capacity（Figure 4）. If the small country has small carrying capacity, then the area in which resource increases will be smaller. As we can see in figure 3, the larger carrying capacity, the probability of taking off for capital accumulation will be increased. It means that the country, which has abundant resources, has an advantage to capital accumulation in the case of no resource trade.

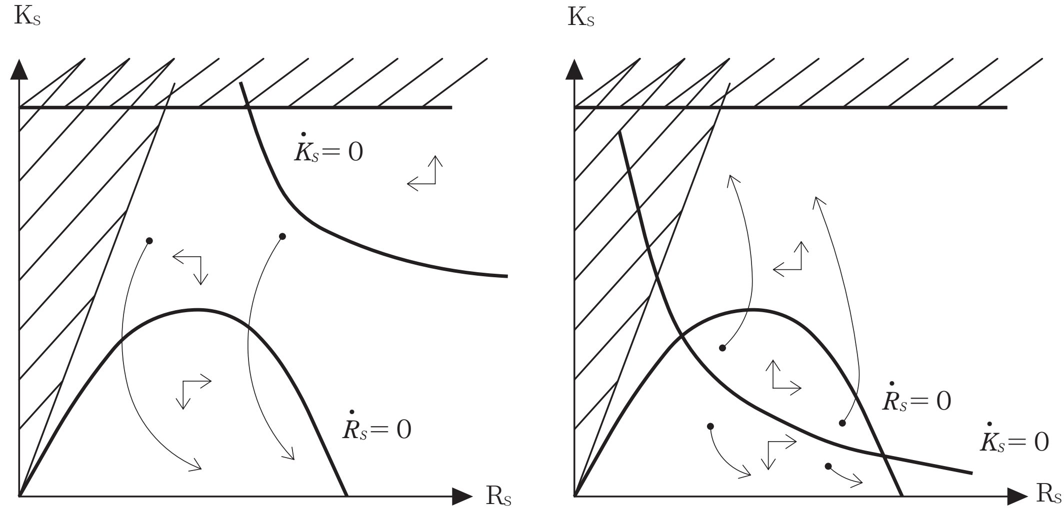
Figure 4 : the effect of carrying capacity



Next we consider the effect of world capital stock. According to the equation (14), the profit rate of manufactured good is decreasing in world capital stock. Therefore a increase of world capital stock causes to shift the $\dot{K}_S = 0$ curve to upward, and an decrease of world capital stock causes to shift the $\dot{K}_S = 0$ curve to downward. An increase of world capital stock causes manufactured good price down, and it cause to change the trade condition of the small country for the worse. A decrease of world capital stock causes manufactured good price up, and it cause to improve the trade condition of the manufactured good in the small country.

Figure 5 shows the effect of world capital stock. It shows that while the early days of world capital accumulation, the small country can easily take off to capital accumulation. But in the world, which has already developed (there are much capital stock), the small developing country can hardly accumulate the capital.

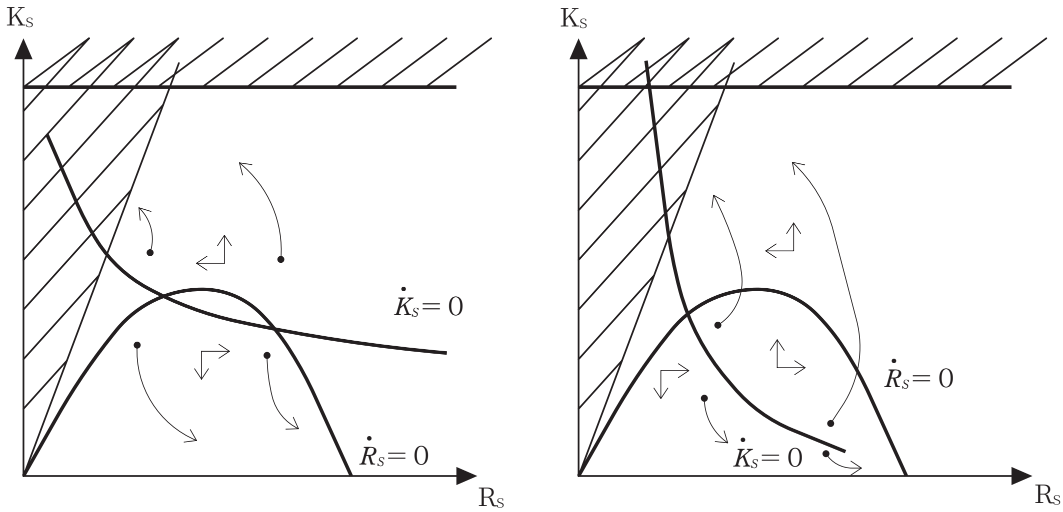
Figure 5：the effect of world capital stock



Large world capital stock　　Small world capital stock

Next we consider the effect of cost elasticity of resource stock. If the extraction cost elasticity of the resource stock is elastic then the change of profit rate with respect to resources, $\partial \rho_s / \partial R_s$, becomes larger because of an immediate change of extraction cost. Therefore the more elastic elasticity to the resource stock, the steeper slope of $\dot{K}_s = 0$ curve according to the equation (15). Figure 6 shows that elastic cost elasticity to resource stock gives advantage to the small country in terms of capital accumulation.

Figure 6：the effect of cost elasticity of resource stock



Inelastic　　Elastic

We consider next tradable cases of renewable resource. We assume that trade cost is zero. Therefore, the small country can use cheaper resource input from own country or another big country. There are two representative dynamic processes, which depend on the amount of renewable resources in the small country. First case is resources in the small country are not abundant. We have already assumed extraction cost of renewable resources depends on the amount of renewable resources in the country. And it was decreasing function. Therefore, scarce resources means high extraction cost in the small country. Then, the country doesn 't use own resources but import cheaper resources from the world. Then input cost of renewable resources is constant. In this case profit rate, ρ_S doesn 't depend on the amount of renewable resources in the small country, R_S. Therefore, the $\dot{K}_S = 0$ curve will be a horizontal line (Figure 7).

Figure 7: resources are not abundant (input cost of a renewable resource, C_R is larger t han world resource price, p_R).

All inputs of resources are imported from world.

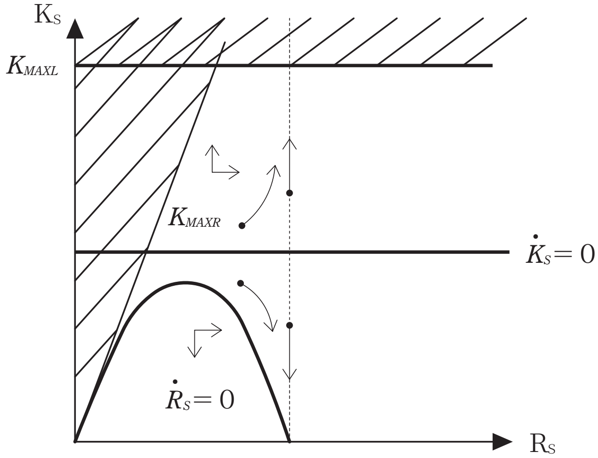
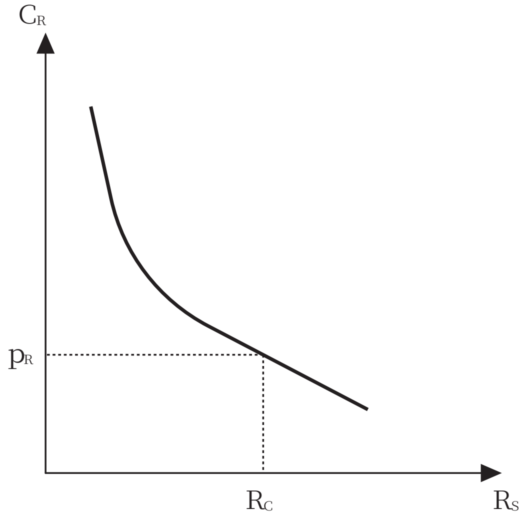


Figure 6 shows that whether the small country can take off for capital accumulation de pends on the level of capital stock at the initial point in the country. If the small co untry starts capital accumulation from upper point of $\dot{K}_S = 0$ line, then the country can t ake off. But if the small country 's economy is below the $\dot{K}_S = 0$ line, then the country c an never accumulate capitals. Development in the small country depends on the initial p osition of the small country in the world. This result is similar to the Krugman 's (1980) uneven development result, which said an initial discrepancy in capital-labor ratios between the two countries will cumulate over time.

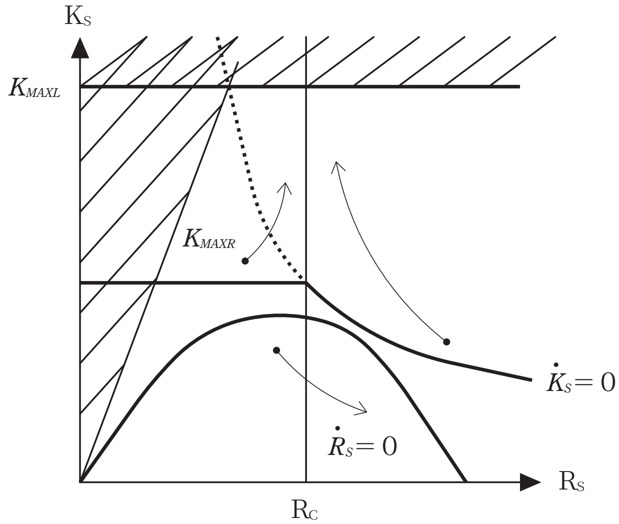
Finally, we consider the case the resources in the small country are abundant. According to equation (10), input cost of renewable resources, C_R, is smaller than world resource price, p_R, while the amount of renewable resource is larger than crucial point, R_C (Figure 8).

Figure 8 : Input cost of renewable resources



In this case, this country is small country in terms of manufactured good. But this country is big country in terms of renewable resources. While the input cost of the country's resources is less than world renewable resource price, the country uses own resources. Figure 9 shows the new $\dot{K}_S = 0$ curve and some pass of capital accumulation in the small country. The result is abundant resources in the country increases the possibility of success for capital accumulation.

Figure 9 : the case of abundant resources



6. CONCLUSION

We analyzed the conditions of taking off for capital accumulation in the small country at last chapter. It was not conditions for sustainable development. But every country has to take off for capital accumulation to achieve sustainable development. Therefore, it is important to recognize conditions of taking off for capital accumulation in order to achieve sustainable development.

Abundant renewable resource was important factor for capital accumulation in every case of the small country economy model. But at the resource tradable case, only the country, which has abundant renewable resource, has advantage of capital accumulation. It doesn't matter for the country, which has less renewable resource, to preserve renewable resource of the country. Therefore, we can conclude that it is no good for preservation of resource to trade resources freely for the country, which has much capital and less resource, like many developed country.

The cost elasticity of resource also played important role to take off the economy. Therefore, we need some policy to reflect the state of resources sensitively. In the real world the state of natural resource is hardly reflected to the market. The developing country, which has no mechanism of reflecting resources to market price, ruined resources of the country, and also cannot take off to capital accumulation because of luck of natural resources and capital stock.

Small estrangement of capital accumulation from advanced country was important for taking off the small country economy. In the real world, there are huge estrangement between developing country and developed country. Therefore, it necessary to invest in developing countries by developed country in order to achieve the even development of the world.

In addition to these, there are some conditions for sustainable development. According to the chapter of pro - growth versus anti - growth, the main problems we have to solve are the physical limits to economic growth and social limits to economic growth. We can achieve eternal economic growth by solving the problems of these limits. But we haven't solved the problems. And we don't have clear answer of decoupling of economic growth and environmental quality. The conclusion of eternal growth also has been left hanging in the air. But one thing we can say is it is impossible to continue economic growth eternally without getting rid of all restrictions of that. Even if there is only one restriction such as social limits or physical limits, then we cannot pursue the eternal growth.

We couldn't have clear conclusion of the arguments of limits to growth by this paper. But we may substitute the conclusion to John Stuart Mill's famous words.

It is not good for man to be kept perforce at all times in the presence of his species. A world from which solitude is extirpated is a very poor ideal. … Nor is there much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature. … If the earth must lose that great portion of its pleasantness which it owes to things that the unlimited increase of wealth and population would extirpate from it, for the mere purpose of enabling it to support a larger, but not a better or happier population, I sincerely hope, for the sake of posterity, that they will be content to be stationary, long before necessity compels them to it.（Mill 1904：454）

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