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The Development of Theoretical Research on Ecological Economics

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Abstract

To solve global ecological crisis and promote the development of economy and society environmental friendly, changing the mode of economic growth is important. However, ecological economics goes beyond environmental economics and critique on traditional economics. New concepts and theoretical research approaches should be brought in to a special stage of economic growth called zero-growth economy and also, shouldering the task of moderating social economic contradictions. Ecological economics takes more complicated approaches to environmental problems and focuses on long-term environmental sustainability and issues of scale. It can been seen that keeping sustainable ability of ecological environment through international cooperation will realize the harmonious development of social economy, the best welfare for human beings, therefore, the view of sustainable development has deep and wide connotations.

Keywords

Ecological economics, Long-term environmental sustainability, Neoclassical economics

1. Introduction

The evolutionary history of human civilization is a progress of promoting and liberating from the nature for human beings, however, it also made the relationship between human and nature become more and more contrary. The development of human civilization has successively gone through three stages, named hunter-gatherers civilization, agricultural civilization and industrial civilization respectively, and the fundamental tone of the relationship between human society and nature is also correspondingly transforming from "relying on natural" to "remoulding the nature" and then "conquering the nature" to the end.

The industrial revolution happened in Western Europe, beginning in the 18th century, took human

history into the stage of industrial civilization, However, two hundred years after that, the economic development of the world is soaring under the premise of exploiting nature indiscriminately. Along with the advancement of industrialization, on the one hand, the resource requirements and pollutant emission are unlimitedly increased. On the other hand, the supply capacity of natural resources and the assimilative capacity of the environment are relatively limited, the contradiction between economic development and the environment is becoming more and more severe. Till the middle of the last century, the contradiction has been greatly intensified, the outstanding performance of which is that environmental hazards emerge in endlessly, and ecological problems tend to deteriorate.

Under such a specific historical background, up from the government, down to the public, people began to re-examine the relationship between human society and nature, reflecting on the disadvantages of the traditional culture, economic concepts and the economic operation mode, furthermore, sustainable development gradually became a consensus in the global scope. Almost at the same time, the economics began to convert sustainably during half a century, and economic scholars began to build a new economic system which aims for sustainable development, thus, ecological economics is an important theoretical achievement during this period.

It is generally believed that the ecological economics is a newly developed marginal discipline, composed of ecology and economics, taking ecological economic system as the research object, based the principle on the ecology, dominated by economic theory, and centered around human economic activities.

Kenneth Boulding, one of the pioneers of ecological economics, published an essay named "Economics of the coming spaceship earth" (Boulding, 1966), which can be seen as the cornerstone of ecological economics. He described the development of global economy as a spaceship, and for the first time, emphasized the concept of circular economy. He thought that the spaceship was an independent system, existing by depleting its own resources, and will be eventually destroyed because of resource depletion. While the only way to extend its lifespan is realizing recycling, and discharging the waste as little as possible. By the same token, the earth is just like a giant spaceship, in addition to the solar energy, all humans material needs is satisfied by a complete cycle. Although the resource system in the earth is bigger than the spaceship, as well as the Earth's lifespan, only circular economy can make the earth remain forever.

Boulding divided the economy into two types, namely the cowboy economy and the spaceship economy respectively. The cowboy economy is a kind of traditional economy, presenting a scene that cowboys are grazing in the field regardless of the damage of grassland. The main characteristic of the cowboy economy is unlimited consumption of natural resources, and regarding the earth as inexhaustible resources, at the same time, it creates large amount of waste, making environmental pollution increasingly serious, all in all, it is characterized by the pursuit of high production and high consumption. To cope with the inevitable result of population explosion, people should abandon traditional economics and replace it with cyclic economy. The new economic thinking advocated by

Boulding was quite advanced at that time, which contributed to the research on resources economy and environmental economy insubsequent years, moreover, it had a profound effect on current "low-carbon economy", "circular economy" and "ecological economy". For the actual needs of social development, many Eastern countries, such as China has attached great importance to the study of environmental problems occurred in the late 1970s.

The emergence and development of ecological economics have significant impacts on social economy. when it is related to global issues, different countries and interest groups start to share common stances gradually concerning environmental protection. After the Second World War, as the importance of environment situation, non-governmental organizations and inter-governmental organizations push relevant countries to establish various international institutions in the field of environment, regulating each member's behaviors, and adjust the relationship between countries in the field of specific environmental problems. A growing number of environmental problems are classified into the adjustment range of international environmental treaties. More and more countries have got the membership to honor the environmental treaties, which means that the stipulated standards of environmental protection will be even tighter than before. The UN's role and function has also been greatly challenged by environmental crisis. During this period, the United Nations had signed over 180 international conventions and agreements related to the environment and resource, such as the Vienna, Convention for Protection of the Ozone Layer (1985), the U.N. Framework Convention on Climate Change (UNFCCC) (1992).

Although, the whole world has put more emphasis on environment protection and relevant theories have emerged, such as welfare economics, environmental economic and ecological economics. Ecological economics itself, however, is not mature and influenced by traditional economic concept which is rooted in current society. On the one hand, there is no firm consensus of many basic problems on ecological economics such as logic starting point, the logical frame, the research object, the subject category and the basic assumptions, which greatly restricts the improvement and spread of the ecological economics. On the other hand, the theory of ecological economy is hardly being translated into powerful policies, thus the ecological economy is not powerful enough to criticize and challenge the traditional economics.

2. The Research Progress of Ecological Economics in Western Countries

2.1 The Period of Classical Economics

The earliest work in relation to ecological economics was advocated by the radiochemist FA Soddy in 1926 (Ropke, 2004). Frederick Soddy, who was a Nobel prize-winning chemist, said that the laws of thermodynamics does finally control the rise and fall of the political system, the lifeblood of business and industry, the origin of the poor and the rich, as well as the total material welfare of human beings. He discussed the role of monetary policy, society and energy played in economic system, criticizing the focus on monetary flows among the economics, all of which was not much accounted of in his time,

but had become important support of the development of ecological economics in the late 20th century (Zencey, 2009). Ecological economics is based on the work of Kenneth e. Boulding, Nicholas Georgescu Roegen, Herman Daly, Robert Costanza and other scholars (Ropke, 2004), and the theoretical origin of it can be traced back to the period of classical economics. During that period, the relationship between land scarcity and economic growth was once a very significant topic, what was more, the so called resource in classical economics was mainly regarded as the population, land and capital.

Physiocrats stress on the important role of natural force in the process of wealth production, which is similar with the theory of sustainable development emphasizing the importance of the nature and ecological environment. The land, as the physiocrat said, does not only include plowland, but also include grassland, pasture, forests, mining, fishery and so on, That is to say, the concept of land in physiocrats, in fact, is close to the concept of natural resources as we said nowadays, which includes the concept of environment and ecology. Smith discussed a situation of primitive society when the land had not yet been privately-owned and thereby the capital had not accumulated, at that time, the national income was in proportion to population size, under this situation, with the growing number of population, the land would be occupied and exploited gradually due to human activities, leading to the occurrence of private ownership of land, however, the division of labor and capital accumulation is sufficient to overcome the negative effects on economic growth because of land scarcity. However, Ricardo was pessimistic about the economic outlook. As populations grow, he thought social demand for agricultural products would continue to increase, and the amount of land is fixed, thus there would appear two trends, one was that people have to cultivate the barrens, another was that there appears the law of diminishing returns. Although there exists increasing returns due to the division of labor and technical progress in the industrial production, but, after the land resources are run out of, the trend of diminishing returns in agriculture will exceed that of increasing returns in industry, therefore, the speed of economic growth will slow down, and step into a standstill--the sluggish growth of population and capital. Political economist Thomas Robert Malthus suggested a more pessimistic view on the impossibility of real progress called the Malthusian Trap. Population increases are limited by the means of subsistence, and the war, famine and pestilence prompted population decline to accommodate the production level (Malthus, 1826).

Most classical economists, including Adam Smith, Thomas Malthus, Karl Marx and John Stuart Mill, admitted the concept of a steady state (Kerschner, 2012). They all had their own ideas about such a state; some equated it with disaster, while others glorified it. Compared with David Ricardo and Thomas Robert Malthus, the stationary state put forward by John Mill was much different. Mill believed that the stationary state is balanced with zero growth, while this kind of state does not mean that human progress is stopped either, instead, spiritual civilization and the society as well as the morality will have much more opportunities to promote further, what is more, people will be expert in the art of good living and become more imaginative(Mill,1909). Therefore, Mill's "stationary state" can

be an opportunity for people to develop a better society.

2.2 The Period of Neoclassical Economics

Classical economics focuses on the relationship between resource scarcity and economic growth, while neoclassical economics focuses on how to set up a system which will be both very effective in allocating resources and stable to balance the relationship between limited resource and social development.

There is a shift in the focus of research core. The sustainable development between ecosystem and socioeconomic system is highlighted in ecological economy. Moreover, ecological economics goes after a different ambition as compared with neoclassical economics. Neoclassical economics regards the maximization of individual economic benefit as its goal, which is deemed as the rational behavior in economic activities, by contrast, maximizing social comprehensive efficiency is pursued by the ecological economy, which means to unify economic, social and ecological benefits organically. Therefore, The historic background and environmental background of ecological economics have determined that it is much different from the way that neoclassical economics has showed in nature. Firstly, the perspective of ecological economics is other than neoclassical economics. In order to overcome the inherent deficiencies of neoclassical economics, the view of ecological economics has reached to the whole ecological system, economic system and social system, all of which are dependent on each other and influence each other.

On the issue of “sustainable development”, neoclassical economists, on the whole, are optimistic. They believed that a free market mechanism can avoid the Malthusian Trap. Firstly, the development of science and technology is sufficient to improve the productivity of land and other resources, which can overcome the trend of diminishing returns. Secondly, the price will make sensitive response to the level of resources scarcity. Thirdly, with the constant improvement of economic development and social life, people tend to choose a smaller family scale, which will cause a decline in population growth rates, resulting in signs of moderation between population growth and resource consumption.

Later, The Limits to Growth, was a book subsequently published to discuss the consequence of interactions between the Earth's and human systems. Its authors, Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, and William W. Behrens III, introduced a new concept of a "stabilized world" to economic analysis. In this book, a computer model is used to simulate the trend of economic operation, presenting that if five variables of world population, industrialization, pollution, food production and resources depletion continue to grow exponentially, “overshoot and collapse” of the global system will been seen in the next 100 years (Meadows, 1972). The most likely outcome will be uncontrolled recession in both population and industrial productivity. They thought that it is necessary to restrain the growth consciously till achieving global equilibrium.

Influenced by “The Limits to Growth”, Herman Daly in 1974 put forward a concept of steady state economy, and also published a book in 1996 called Beyond Growth: The Economics of Sustainable Development, which can be regarded as an eternal classic in the school of ecological economics, again

in 2004, Herman Daly and Joshua Farley co-published a book called 'Ecological Economics: all of the and Applications', which firstly gave a relatively complete theoretical framework of Ecological Economics. The ‘Steady State Economy’ (SSE) made by Herman Daly aims for a sustainable condition that birth rates equal death rates, and saving/investment equals depreciation, in other word, it will never exceed ecological limits, finally, a distributionist institution ought to secure social justice by introducing minimum and also maximum income limits.

Begin from Ricardo's assumption of a stationary state, through Malthusian Trap, Mill's stationary state, “Economics of the Coming Spaceship Earth” written by Blouding, “The Limits to Growth”, and finally Daly's Steady-State Economy, a clear logical line for people to realize the restrictive function of environmental ecology influencing social economic development can be seen. Along this clue, the blueprint for the future economic growth designed by human beings would be more and more rational, aside from that, a large number of scholars are making groundbreaking contributions to the development of ecological economics. Lester Brown, the author of 'Eco-Economy: Building an Economy for the Earth' (2001), is one of the most important voices in the world, regarding the creation of a new conscience of humanity toward a sustainable society.

However, Herman Daly claims that sustainable development can only be achieved by entirely changing nowadays social growth based on old economic system. Every government wants to achieve the goal of sustained and rapid economic growth, which is inherently incompatible with sustainable development, unless sustainable development is a weak sense (as explained below), which accepts substitutability between human-made capital and natural capital. This is currently done by neoclassical economists, the roots of which are based on a value concept. Some authors argue that it is this value concept combined with the panacea of technological progress, allows neoclassical economic theory to believe in unlimited economic growth (Kerschner, 2012). Nevertheless, ecological economics is still in a subordinate status. Within the perspective of the construction of theoretical system, “The Ecological Economics: all of the Applications”, published in 2004 and co-authored by Herman E. Daly and Joshua Farley, is arguably representing the highest level to build a theoretical system in ecological economics, which has tried to make new statements of important economic problems related to mainstream Economics from the perspective of Ecological Economics, but it always shows disadvantages in its theoretical system -- as the significant cause to make contradictions between nature and the society intensified--the population and technology are basically not involved in this book. Later in the journal of Ecological Economics, citation analysis is used by Robert Costanza, David Stern, Lining He, and Chunbo Ma (2004) to examine which books and articles have had the most influence on the development of ecological economics. However, citation analysis is criticized for its controversy and the journal Ecological Economics has itself been criticized for swamping the field with mainstream economics.

3. Methods, Contents and Main Points of the Study

3.1 Contents and Main Points of the Study

Firstly, The study of ecological economics related to the logical starting point and frame is under the scope of ecological carrying capacity, and puts forward a logic frame based on I=PAT equation. (I=PAT is a formula to describe the impact of human activity on the environment.)

Secondly, the belongingness of ecological economics. Due to the combination of ecology and economics, ecological economics is sometimes regarded as an independent branch or a branch of ecology or a school of economics, from those three perspectives, they research on the same object with different views, thus it is concluded that ecological economics is considered on ecological constraints for economics.

Thirdly, the basic assumptions about ecological economics. This study analyzed the rational hypothesis of ‘economic man’, opposing the reason for replacing ‘altruism hypothesis’ with ‘economic man hypothesis’.

Fourthly, the successive relationship between ecological economics and mainstream economics in historic process. It can be pointed out that the ecological economics advance the mainstream economics into a new stage of social development, and these two subjects can be spliced into a successive, longitudinal and complete theoretical system.

Fifthly, the relationship between ecological economics and similar subjects. Based on sustainable development, it is possible to put forward a image of integration for some small branches on the platform of ecological economics.

3.2 The Research Object of Ecological Economics

Regarding the research object of ecological economics, different scholars have various views, but there is a common consensus that ecological economics is a study of ecological system, and mainly focus on the relationship between social economic system and global ecosystem.

Firstly, the emphasis on the economic aspect of the ecosystem. In this view, the compound system of ecological economy is regarded as the subject to explore the interrelation between the natural ecology and human economic activities.

Secondly, the research on social factors in ecological changes. In this view, the ecological system and social system should be regarded as a whole, and ecological tools are used to measure economic utility.

Thirdly, the emphasis on the contradictory movements of ecological economy. In this view, ecological economic system is a contradictory unity of ecological system and economic system, which can be summarized as the structure, function, behavior, operating mechanism and regularity of the complex organization.

Finally, the research of ecological economics lies on how to run the social economic system effectively to coordinate with the world’s ecosystem, maintain the sustainable development, and further realize the sustainable development of the whole social economic system.

4. The Challenge of Ecological Economics to Traditional Economics

4.1 The Hypothesis of Economic Person -- Ecological Demands of People

The logic of traditional economics is beginning with the hypothesis and abstraction of rational economic man. In economics, the concept of “economic man” describes one kind of person who always choose to maximize profits when facing different opportunities in various economic activities. The desire of possessing wealth blindly by economic man leads to a consumption mode which will eventually run out of resources, destroy the environment, and worsen the relationship between human beings and the nature, consequently, the economic man turns to be an unsustainable man, and the hypothesis of economic man leads to a crisis of economic theory and economic practice, namely unsustainable economic development, ecological crisis, and so on. The deep-seated root of today's ecological crisis and economic difficulties is the crisis of the concept of economic man, which need to be modified obviously, that is to say, it is necessary to realize the ecological requirement of economic man. Economic man should not only consider utility maximization in the way of pursuing economic benefits, instead, it is more important to consider ecological responsibilities and seek ecological benefits.

4.2 The Way to Substitute Marginal Analysis

Marginal analysis is the most general method used in neoclassical economics. The term of margin implies many basic assumptions, such as substitutability, value monism, opportunity cost and market equilibrium. However, it is reluctant to apply the marginal analysis to ecological economics, which has obvious limitations (Cowdy, 1997). For example, if a certain species in the ecological system increases or decreases, then the integrity of the whole system will be dramatically affected by the change, these effects of which has characteristics of complexity and variability, however, the change of some other species has a little influence, thus different species exert different influence on the ecosystem. Biodiversity has a feature of functional transparence, the contribution of a species to ecosystems can only be identified after reducing or increasing. In addition, even under the background of economic market, people will also change the goods and services according to market principle rather than the law of marginal utility.

On the way of Marginal analysis, the cognition of economic change is step-by-step, continuous and gradual, which is an incomplete evolutionary process. while in the view of ecological economics, the driving force of social development and biological evolution is random and impacted by non-marginal principle. For example, if not the sudden event "911" occurred in 2001, the new changes in modern international commercial insurance and aviation industries would be difficult to understand. The real evolution is selected by nature, happens accidentally and randomly, what is more, it is impossible to keep the stability of the other subsystems when a certain subsystem is experiencing turbulence. However, this kind of qualitative change and non-marginal change are cannot be contained by neoclassical microeconomics (Van den Bergh & Gowdy, 2003).

An alternative for the method of marginal analysis used by ecological economics is complex adaptive system. In recent years, there are two basic observational conclusions on the research for maintaining

the diversity and complexity of the society, economy and ecology in ecological economics. Firstly, for all kinds of problems and crisis, the modern development policy is effective in the short term, but in the long term, it will be rigid and outdated. Departments of economy and society are more and more dependent on the ecosystem, while ecosystem has become more and more fragile, and the government appears to be a lack of trust. Secondly, the method of complex adaptive system analysis argued that regarding the loss of natural capital as a negative flow is advantageous for the supervision department to attach great importance to the recovery of natural capital and keep the stability of the general systematic boundary. This kind of view in ecological economic regards the elasticity as an important index for ecological health, and the ability of adapting to unexpected and unforeseeable changes is also beneficial to the stability of the whole system.

Another alternative path of marginal analysis is to use the model of expanded input-output, which can investigate the direct and indirect effect on the dramatic transition of economic structure. Compared to the general equilibrium analysis used in neoclassical economics, the framework of the IO Social Accounting allows for a more flexible definition of economic activity. The IO Social Accounting provides systemic analysis method with enough and effective informations, and those informations are the basis of evaluating the comprehensive effects for substitutional policies on ecology, economy and the society.

4.3 The Challenges of Element Substitutability

Traditional economics is based on a view of resource scarcity, and claims to the most effective configuration. However, the resource scarcity advocated by traditional economics refers in particular to the scarcity of specific resources, which can be substituted for technical progress or other resources, but the fact is that all resources are limited in earth's ecosystem.

The Cobb–Douglas production function, representing the technological relationship between the amounts of two or more inputs, can be seen the most basic production function in traditional economics, using the following expression:

$$Y = AL^{\alpha}K^{\beta}$$

where Y is total production, A is total factor productivity, L is labor input, K is capital input, and α and β are the output elasticities of capital and labor respectively. Known from Cobb-Douglas production function, if any one of those two inputs is zero, the output will be zero too, thus, for the production, each factor of production is necessary, and there is no element can entirely substitute another one. In fact, the two factors of labor and capital can be substituted each other within a certain range, however, if it exceeds the physical limit of labor, there will be no more output even through spending on capital element increased dramatically.

Actually, the production activity in human society can be divided into two major categories, namely organic production and inorganic production. Organic production is mainly agricultural production depending on solar energy to photosynthesize.

Inorganic production includes physical production and chemical production. The former one is based on existing materials on the earth for processing and combination, and the raw material must meet a

certain proportion for inputting. The latter one is generating new material through chemical formula, which requires a certain proportion between elements, otherwise the chemical reaction will be failed due to disproportional elements.

Traditional economists believed that the price depends on the scarcity. If one kind of elements becomes scarce, accordingly, the price will be higher than before, then the operator will economize it, until the price becomes too high to tolerate, finally, operators will seek a substitute. However, it is difficult to find a new alternative resource in reality , in fact, not only is the non-renewable resource limited in the nature, but so do the renewable resource, which can be transferred to nonrenewable resource when the usage exceeds the regenerative capacity.

4.4 Laws of Entropy

Ecological economics is a study from the most widely perspective of ecological system and economic system， playing an increasingly important role in researching the sustainable economic development, and utilizes ecological footprint, virtual water, emergy analysis and entropy to make important theoretical progress. As the economy system increasingly grows, people gradually realized that it is necessary to achieve the goal of improving human welfare on the basis of controlling the whole scale through system evolution, the improvement of the quality, structure and service, rather than blindly pursuing the growth of the number or scale.

The basic framework of traditional economic theory is researching a flow as shown in figure one, which is comprised of producer (manufacturer) and consumer (household). The goods is produced by manufacturers and supplied for households, thus the price is decided by the supply and demand. At the same time, productive factors including land, labor and capital are provided by families, the price of which is determined by the supply and demand in factor markets. Cyclic process is reversible from the standpoint of traditional economics, however, Georgescu-Roegen argued that all natural resources are irreversibly degraded when utilized in economic activities.

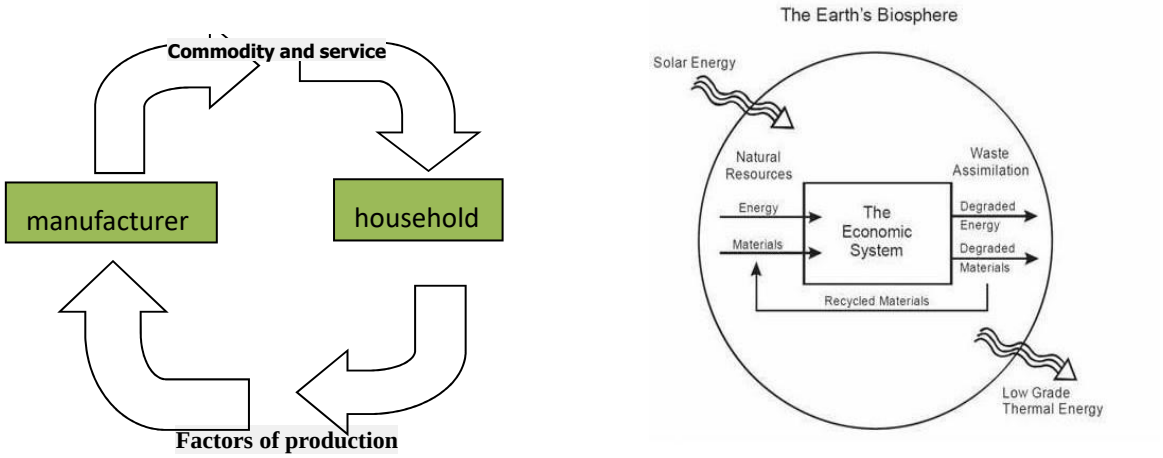

Figure 1. The Isolated System and Natural Resources Flow through the Economy and End up as Waste and Pollution

Introducing the term 'low entropy' for valuable natural resources, and the term 'high entropy' for valueless waste and pollution, Georgescu explains that it is irreversible to transform low entropy into high entropy from a physical point of view in economic process, thereby providing an unfailing supply of natural resources for people to live on, which lead to the reason of resource scarcity. According to the entropy law, the irreversibility has determined that it is possible to recycle material resources, but only by using up some energy resources plus an additional amount of material resources; and energy resources, in turn, cannot be recycled at all. Mistaken for a perpetual motion machine and ignoring the importance of supply, the circular flow cannot be recycled directly in economic system. There is no doubt that it is crucial to recognize the supply coming from external system, which is unnoticed by traditional economists.

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5. The Development of Ecological Economics

5.1 How to Integrate the "Legacy" of Traditional Economics into Ecological economics

There still is a problem that how to integrate the ecological economics into the mainstream economics. In the process of establishment, development, and further mainstreaming, it is important to correctly cope with the relationship between ecological economics and traditional economics. Although the theoretical background, basic concept, principle and even world view of the ecological economics are quite different from traditional economics, it should not be the reason to negate the traditional economics.

First of all, ecological economics and traditional economics can be integrated into a theoretical system possessing intrinsic consistency. Traditional economics makes an assumption that people keep away from the limit, which just likes keeping away from the ultimate speed of a single photon or the light in physics, while in economics, the limit refers to the carrying capacity of the earth. Therefore, classical theory cannot work well when it is close to the limit. That is to say, before achieving the ultimate carrying-capacity of the earth, economic activities will not pose a threat on the stability of ecological system yet, and the contradiction between economic system the ecological system is not very prominent, at that time, the theory of traditional economic is able to exert its influence effectively, however, when the

scale of economic system is too large to be carried by the ecosystem, the theory of traditional economic will be invalid, under this background, the theory of ecological economics need to be used to guide the operation of the economy. Based on this understanding of the facts, the relationship between traditional economics and ecological economics can be considered as two connected segments representing two successive transient process in one theoretical system, the treatment of which embodies the respect for the traditional economics, and also can integrate the two theories into a scientific system within intrinsic consistency.

Secondly, the accumulated experience in policy making and the practice of economic management based on traditional economics are still can be used and referenced by ecological economics. In order to realize the goal of sustainable development, ecological economics emphasizes the improvement of human welfare under the premise of protecting ecological under the premise of protecting ecological foundation which is relied by people for existence. Therefore, on the one hand, we need to develop new policy tools, such as ecological tax, on the other hand, it is also necessary to rely on the previous policy system. For example, the government can make use of green ideas to guide and standardize some financial projects, what is more, government purchase can change the technical standard of the industrial community, resulting in a direction change which is more conducive to ecological protection, finally, it can achieve the goals of sustainable development.

Finally, it requires that the green environment must be emphasized. Ecological economics also has a close relationship with the deep ecology. Many viewpoints of deep ecology are guiding the critical environmental theory. What's more, ecological economics attaches more importance to the sustainability. It requires stronger sustainability than usual. These important elements make the traditional environmentalism critical.

5.2 Green Accounting: from Weak Sustainability to Strong Sustainability

Since the economic growth is increasing, traditional method of GDP accounting cannot reflect the negative impact on resources and environment, in the early 1960s, it has already drawn a lot of criticism, thus, scholars are trying to find a new way to account GDP environmentally friendly. The pioneer of this field, Nordhaus and Tobin have first proposed Measure of Economic Welfare(MEW) in 1973, and advocated that environmental costs such as the pollution generated by economic behaviors should be deducted from national income.

The main goal of green accounting is to measure the sustainability more accurately. there are two opposing sustainability paradigm in ecological economics at present: the weak sustainability paradigm and the strong sustainability paradigm. The fundamental difference between these two kinds of paradigm lies in how to determine the relationship between natural capital and man-made capital, that is, if the relationship between natural capital and man-made capital is substitutable or complementary.

Based on neoclassical economics, implying a basic assumption that there is no essential difference between the welfare generated by different types of capital, Weak sustainability insists the almost perfect substitutability for the relationship between man-made capital and natural capital. Because of

the substitutability, using natural capital can create enough man-made capital to make up for the loss of natural capital, even if the stock of natural capital drops more than before, it is believed that the economy is sustainable. Strong sustainability is based on ecological economics, insisting that it is important to maintain various types of capital stock, especially the stock of natural capital. Because, some of the natural capital are irreplaceable. 0'onnor pointed out that economic development includes the management of the economic system and ecosystem, and the improvement of human well-being not only depends on the products and facilities, but more on environmental services.

Indeed, at present, weak sustainability is used routinely in green accounting, the reason of which is that the theoretical system of neoclassical economics has been quite completed as a theoretical basis for the weak sustainability, therefore, economists can skillfully research the problem of weak sustainability along the existing theoretical system of neoclassical economics, and ensure the preciseness and scientificity of the theoretical research. However, the limitation of weak sustainability is obvious to be found from an ecological standpoint. The elasticity of substitution for natural capital is zero, and it is irreversible, once lost, natural capital will not be able to restore. It is not acceptable to compensate for the loss of environmental value by adding the value of man-made capital.

The main characteristics of green accounting is that it has fully realized the damage of social welfare made by the loss of natural capital, which is agreed by both weak sustainability and strong sustainability. While strong sustainability places more emphasis on the unsubstitutability of natural capital, which puts forward higher requirements on sustainability. Because of its theoretical basis, strong sustainability failed to become the mainstream in economics. Ecological economics is a branch of economics, but some analyses are not the same as the neoclassical economics, from this point of view, ecological economics should bring important economic revolution, but due to the imperfect and dependent theoretical system, which makes the strong sustainability is often criticized by neoclassical economists. However, objectively speaking, it is unfair to criticize the strong sustainability from the theoretical method and standard of neoclassical economics, because strong sustainability in fact is not based on these theories, methods and standards.

6. Conclusion

Critical ecological theories focus on the systemic level believe that there are limits to growth, carrying capacity and that the planet is a closed system. Accordingly, it is important to shift, at minimum, to a zero-growth, steady state economy. Ecological economics contains more items and meanings compared with the traditional economics, which includes sustainable development, weak sustainability and strong sustainability. Ecological economics pays much more attention to green, in other words, dark green. The core issue and research theme of ecological economics have been transfered from the perspective of coordination development to the sustainability of eco-economy. The mainstream school of international ecological economics emphasizes that ecological economics tends to solve the current sustainable development issues for the human economic society and its life support system.

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