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Choices from an Ecological Economics Perspective: Strong Sustainability V.S. Weak Sustainability

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Abstract

The school of ecological economics has proposed the idea of 'resource substitution', in which natural resources are gradually replaced by man-made resources in order to gradually reduce human dependence on natural resources, in order to balance environmental protection and economic development, the two most important goals of humanity today. In order to prove the feasibility of this idea, academics have proposed two different perspectives: 'strong sustainability' and 'weak sustainability'. The main objective of this paper is to demonstrate the viability of the resource substitution theory and how to weigh the degree of substitution between man-made and natural resources. The paper first introduces the basic framework and analytical logic of ecological economics and the criteria for assessing the viability of the perspective, then presents regional, national, and global case studies of the positive and negative impacts of the substitution of natural resources by man-made resources in different contexts, and finally draws conclusions based on the assessment criteria.

Keywords

Ecological Economics, Sustainability, Man-made capital, Natural capital

1. Introduction

As the Sustainable Development Goals (SDGs) for 2015 are being set and mankind's research into sustainable development intensifies, the question of how to achieve sustainable development becomes paramount (Brundtland, 1987). In particular, the current growing environmental problems, and the difficult goal of limiting temperature rise to 1.5 degrees Celsius by the end of the century require mankind to place sustainable development in the most critical position. In order to be able to combine environmental protection and economic development at the same time, the ecological economics school has proposed the solution of replacing natural capital with man-made capital and has attempted to test the feasibility of this approach (Daly, 2014). In order to study the feasibility of resource substitution, one first needs to understand ecological economics. This is a discipline that integrates the goals of both ecological conservation and economic development, studying the links between contemporary economic, social, and ecological structures.

This research has led to a clear understanding of the value of natural capital. Ecological systems, biodiversity, and natural resources have been essential for human survival and, in earlier times, for human socio-economic development (Block, 1990). However, the simultaneous growth of social productivity and human needs has led to severe depletion and degradation of natural resources in the wake of the industrial and technological revolution. The theory of "weak sustainability" was formulated in reaction to this, which proposes that human-made capital can be substituted for natural resources to maintain economic expansion and human well-being (Neumayer, 2003). The global community has vigorously debated whether natural resources are irreplaceable, with opponents disputing this opinion.

Overall, this paper will introduce and analyze the concept of resource substitution from an ecological economics perspective, with a focus on weak and strong sustainability. The paper aims to provide policymakers with an analysis

of the feasibility of replacing natural resources with man-made products, by examining examples of resource substitution that exist at different scales and concluding that the extent of resource substitution needs to be judged specifically on the basis of the characteristics of the resource itself.

2. Theoretical framework of ecological economics

2.1 Basic concepts

Formally developed in the 1980s, ecological economics focuses on the temporal and spatial interdependence and coevolution of human economies and natural ecosystems (Ropke, 2004). In contrast to traditional economics, ecological economics to a large extent reflects the human ecological footprint of economic activity and considers ecology as the basis for economic development, stressing the importance of the conservation of ecosystems for sustainable economic development (Costanza, 1992). Some economists argue that natural capital should also be included in the typical capital stock analyses for land, labor, and financial capital. It advocates sustainable development with a focus on human well-being and is concerned with the balance between economic development and environmental protection (Costanza, 1992; Ropke, 2004; Neumayer, 2003). These scholars argue that sustainable development requires a balance between economic development and environmental protection so that people's well-being can be enhanced.

2.2 Natural and man-made capital

Natural capital and man-made capital are two concepts that are used in the economic and environmental sciences (Hardwick, 2010). Natural capital is the Earth's natural resources and ecosystems, such as land, water, forests, minerals, air, plants and animals, and so on. It is the foundation of human society, providing humans with all the material and energy they need to sustain life and economic activity (Hardwick, 2010). Man-made capital is what human beings have created on the basis of natural resources and technology. It includes structures, facilities, infrastructure, plants, machinery, technological installations, and so on. This type of capital is used to satisfy constantly renewing human needs and is the result of human processing and production. These two types of capital are closely related (Hardwick, 2010). For example, natural capital provides important functions such as waste management and environmental regulation, in addition to providing raw materials and energy for man-made capital. Therefore, a balance between natural and man-made capital, ensuring the rational use of natural resources while protecting and maintaining the integrity and functioning of ecosystems, is necessary for the sustainable development of human society (Folke, Carpenter, & Elmqvist et al., 2002).

2.3 Weak and strong sustainability

The strong sustainability perspective holds that natural capital and built capital are irreplaceable and that both need to be protected and maintained to ensure sustainable development. Strong sustainability therefore requires that economic development is accompanied by respecting and protecting the environment, ensuring that natural resources are renewable and ecosystems remain intact (Neumayer, 2003). The weak sustainability view considers some substitution between natural and anthropogenic capital. According to the weak sustainability perspective, sustainable development can be achieved as long as overall technological innovation and economic growth can compensate for the loss of natural capital, even though the depletion of natural capital may have a negative impact on certain ecosystems or species (Neumayer, 2003). In practical terms, sustainable development often involves combining both perspectives and seeking to balance the economic, environmental, and social dimensions (Daly, 2014).

3. Case study: resource substitution analysis at different scales

3.1 Regional scale—the Amazon rainforest region

3.1.1 Background

As the largest tropical rainforest on Earth, the Amazon rainforest in South America is known as the "lungs of the planet" and is one of the world's most typical ecosystems, vital to the stability and health of the planet (Butler, 2020). However, due to local economic development and the need for resource extraction, the Amazon rainforest is under serious threat of destruction, including illegal logging, illegal hunting, large-scale agriculture, expansion of pastoralism, and mining activities (Amazon Aid Foundation, 2021). Forest destruction not only leads to the loss of

biodiversity but also to problems such as soil erosion, water pollution, and climate change (Butler, 2020). Some scholars have suggested that human demand for timber can be met by planting plantation forests following the destruction of the Amazon rainforest (Butler, 2020; González & Kröger, 2020).

3.1.2 Resource substitution analysis

a) Ecological impacts: The Amazon rainforest is a long-established and complex ecosystem whose role is not simply one of climate regulation and freshwater storage (Butler, 2020). Once destroyed, the damage caused is incalculable: for example, a significant reduction in biological diversity, increased climate warming, disruption of the global water cycle, increased weather extremes, severe regional soil erosion, and so on (Butler, 2020). Planted forests take time to reach a relatively mature state, and these consequences cannot be repaired in a short period of time, which could bring doomsday for mankind (González & Kröger, 2020).

b) Economic impact: Although planted forests can provide economic value in terms of timber and fiber material, they cannot fully replace the functions of the Amazon rainforest. Once the Amazon rainforest ecosystem is destroyed, many industries, such as agriculture, forestry, and tourism, will be devastated (Brice, 2022).

c) Social impact: The Amazon rainforest spans nine countries in South America, and if the land is exploited by humans, the ensuing territorial disputes and resource grabbing could cause serious social unrest and contribute to regional stability (Butler, 2020).

3.2 Country scale - Germany's energy transition

3.2.1 Background

Over the past decades, the German government has been a major investor in renewable energy projects (IEA, 2020). They have updated energy efficiency standards, supported renewable energy research and development, and introduced a series of laws to support the development and use of renewable energy by introducing various subsidies for businesses, and people (IEA, 2020). These policies and measures have contributed to Germany's green energy transition, not only by reducing reliance on fossil fuels but also by increasing the economic efficiency of the renewable energy sector. In terms of resource substitution, Germany's goal is to replace traditional fossil fuels with renewable energy sources (Hager & Stefes, 2016).

3.2.2 Analysis of resource substitution

a) Ecological impact: The use of renewable energy sources as an alternative to fossil fuel energy can control greenhouse gas emissions and reduce air pollution (IEA, 2020). This not only helps to solve the climate problem but also reduces the human exploitation of fossil fuel resources. Protecting local air quality in Germany while also reducing the damage to the soil from the extraction of fossil fuels (US EPA, 2019).

b) Economic impact: Promoting the development of the renewable energy industry creates new jobs, boosts economic growth, and increases social enthusiasm for consumption, contributing to the structural transformation of the economy and sustainable development (IEA, 2020). However, there will also be problems with increased costs associated with the phasing out of traditional industries and the need for significant R&D funding in the early stages of the development of the renewable energy sector, which will lead to a decline in economic efficiency in the short term (IEA, 2020).

c) Social impact: The development of the renewable energy sector will provide employment opportunities for society, reduce unemployment, and stabilize social order (IEA, 2020). At the same time, the development of the sector will allow the German government to move away from energy dependency and improve the stability of the energy supply (Hager & Stefes, 2016).

3.3 Global scale—Food system innovation

3.3.1 Background

Each cultural system in the world has its own unique traditional foods, but traditional human dietary systems are beginning to be questioned due to the many problems associated with traditional foods, such as pollution of the environment and destruction of biodiversity. In terms of resource substitution, the way forward for future dietary systems is to achieve a more sustainable, healthy, and equitable diet by promoting sustainable agriculture and food production patterns and reducing dependence on resource-intensive foods (Filipe et al., 2023).

3.3.2 Analysis of resource substitution

a) Ecosystem impacts: Sustainable agriculture and food production patterns, reduce the negative impacts on farmland ecosystems by planning farmland, reducing the use of chemical pesticides, and producing food (or food ingredients) in a planned manner (GEE, 2021). This will help to protect the stability of farmland ecosystems and improve the efficiency of agricultural production and the safety of agricultural products, within the limits of what farmland can carry (Ritchie & Roser, 2020).

b) Economic impact: The transformation of the food structure is not only an upgrade of the food production chain but also promotes the development of food technology and provides consumers with better-quality food (GEE, 2021). On top of this, it can create jobs and stimulate the population's consumption. In addition, sustainable food systems can reduce food waste and increase resource efficiency, thereby reducing economic costs (Filipe, Lomba, & Honrado et al., 2023).

c) Social impact: Improving food security and equity entails ensuring that all countries around the globe have access to nutritious food and reducing inequalities in the distribution of food resources (Ritchie & Roser, 2020). In addition, sustainable agriculture models can contribute to the development of rural communities, promote agricultural refinement, and increase farmers' incomes (Ritchie & Roser, 2020).

4. Assessing the feasibility of resource substitution

4.1 Human potential

Human beings have a strong initiative to develop alternative resources. At present, mankind is facing serious damage to the ecological environment and increasingly serious climate problems . Therefore, all mankind must work together to achieve sustainable development and to promote social, economic, and ecological improvement (Neumayer, 2003). In addition, human beings have the unique ability to create and design more artificial resources in the future with the advancement of technology (IEA, 2020).

4.2 Level of technology

Technological progress and innovation play a decisive role in the search for alternative natural resources. For example, the widespread use of solar and wind energy in most countries is the result of technological innovation (Energy gov., 2023). This renewable energy source can reduce mankind's dependence on fossil fuels, effectively mitigate the problem of climate warming, and also reduce the overexploitation of resources (IEA, 2020). As technology advances, mankind can discover new, more efficient, environmentally friendly, and sustainable alternatives to traditional resources, increasing economic efficiency while reducing the destruction of natural resources.

4.3 Current limitations

Although mankind is actively seeking alternatives, there are several limitations and challenges. Firstly, many natural resources are necessary for humans, such as pure water and oxygen, and these resources are difficult to replace completely with man-made resources (Butler, 2020). Natural resources are unique and have evolved over a long period of time, and it is difficult to produce an identical alternative resource at the current level of human technology (Dincer, 2000). On the other hand, resource substitution can be influenced by many social factors (GEE, 2021). For example, when clean energy replaces traditional fossil fuels, the fossil fuel industry, once the most important sector in the world's economic structure, is bound to be affected and the resulting economic crisis could jeopardize the social stability of countries around the world (US EPA, 2019).

5. Conclusion

Ecological economics provides a theoretical framework for analyzing resource substitution and has led to thinking about how to achieve sustainable development (Costanza, 1992). In this regard, the academic community has developed two perspectives, 'strong sustainability' and 'weak sustainability', which present the relationship between natural and man-made resources, and have led to a debate on which is the most effective and which can replace natural resources (Neumayer, 2003). Which is the most effective type of sustainability? Can man-made resources completely replace natural resources?

After analysis, we can see that man-made resources can reduce the damage to limited natural resources. For

example, using timber resources from planted forests to replace timber from the Amazon rainforest can protect native forests and provide an effective alternative to timber demand (González & Kröger, 2020). Furthermore, the promotion and application of renewable energy can reduce dependence on fossil fuels, reduce greenhouse gas emissions, and help combat climate change (US EPA, 2019). In addition to the ecological advantages, there will be many social values.

However, at the same time, we must also recognize that resource substitution has its own disadvantages. Due to current technical and economic constraints, some alternatives may not be able to achieve the performance or benefits of virgin resources. For example, ecosystems in planted forests do not have the complexity of natural rainforest ecosystems (González & Kröger, 2020). In addition, the promotion of resource substitution policies can be influenced by social factors, which can lead to opposition from some interest groups and even economic unrest (Dincer, 2000).

In short, resource substitution is complex and diverse. Policymakers must actively seek sustainable solutions that achieve economic growth, environmental protection, and social justice simultaneously, based on a comprehensive assessment of the pros and cons of alternatives. This requires human beings to achieve interdisciplinary cooperation, promote scientific innovation, and enhance policy support to work together towards eco-economic and sustainable development goals.

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