The 6th International Conference on Economic Management and Green Development (ICEMGD 2022)
DOI: 10.54254/2754-1169/3/2022746

Conceptual Analysis of the 3E System Based on New Human Capital Theory

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Abstract: The contradiction between energy supply and demand, environmental protection, and economic development is becoming more and more obvious. How to coordinate and balance the relations between energy, environment, and economy has become a common concern of scholars. In this context, the Energy-Environment-Economy (3E) system is gradually maturing, and up to now, the 3E system has been widely used in the evaluation of the development of various regions. In order to make the 3E system closer to the real social situation in the application, the measured results have more practical significance. Based on the new human capital theory, this paper summarizes and analyzes the relevant research literature, and discusses the influence of population on the three subsystems of energy, economy, and environment in the 3E system. It is found that population has an impact on each subsystem, among which it is worth noting that the impact of population on the environmental subsystem is diverse and complex, so the current situation of the 3E system is different from the theory. The article examines the impact of population on the 3E system in order to optimize and complement the 3E system.

Keywords: new human capital theory; 3E system; economic development

1. Introduction

1.1. Background

As an important material basis, energy plays an indispensable role in human survival and social development, but most of the energy sources commonly used today are non-renewable. With globalization and the rapid development of the economy, industry, and technology, the demand for energy is also rising year by year. At the same time, due to the geographical environment and the level of technology, the supply of energy is gradually unable to meet the needs of the rapidly developing economy and society, and the problem of imbalance between energy supply and demand is becoming more and more obvious, so how to use limited energy to satisfy the efficient development of the economy while taking into account the sustainable stability of the natural environment has become a common concern and research problem of major scholars.

At the early stage of research, scholars from various countries used economic theories to study the configuration of environment and energy and gradually formed two major research systems, economy-energy, and economy-environment. At the same time, the interdisciplinary study of energy-economics was formed. Energy economics believes that in the process of energy development and

DOI: 10.54254/2754-1169/3/2022746

utilization, there are various economic phenomena such as market, price, supply, and demand, etc. Energy and economy are closely related and inseparable.

With the in-depth development of the two-dimensional system of economy-energy and economy-environment, scholars have gradually found that energy, economy, and environment are closely related to each other as influencing factors. Therefore, some scholars gradually introduced environment as an important factor into the two-dimensional system of economy-environment for a more in-depth and comprehensive study. Since 1980, the three-dimensional system of energy-environment-economy (3E) has gradually taken shape, and the issue of the integrated balanced and coordinated development of the three has been widely studied.

1.2. Significance and value of the study

From the perspective of the overall development of the system, the human social system, in which the population is an indispensable element, continuously obtains material and energy from the environment to meet the needs of production and life, while human activities have a non-negligible impact on the environment. In the relationship between human beings and the environment, human beings are both the root cause of damage to the ecological environment and an important force in building it. In the relationship between population and ecological environment, it is necessary to transform the population into an active force in protecting and building the ecological environment. One of the core issues is to put human resource development at the center of sustainable development [1]. The new human capital theory assumes that different social environments and levels of education give people different competence, which is directly related to salaries and thus has an indirect impact on the economic environment. The population can no longer be calculated simply from the perspective of material production and consumption, but the impact of human capabilities on the economy, environment, etc. should be comprehensively considered. The 3E system is based on three subsystems-energy, environment, and economy, exploring the coordination and balance of the three, which has important reference value for the use and allocation of energy, and prevention and control of environmental pollution, etc. If the human is added into consideration, the system can be made more perfect in the overall perspective, and the dynamic balance of the system is also closer to the real situation of the social system.

2. Literature review and theoretical foundations

2.1. Concepts of the 3E model

The 3E model refers to the study of the energy-economy-environment system, which mainly refers to the study of the methods and models for measuring the degree of interaction between the three subsystems of energy, economy, and environment in order to realize the integrated balanced and coordinated development of the social development system. The research on the measurement methods and models of the degree of interaction among the subsystems in order to achieve the integrated balance and coordinated development among the three subsystems of energy, economy, and environment in the social development system. At present, it is generally believed that the 3E system is a complex system formed by organically combining various elements in the social, economic, cultural, and ecological context [2].

In terms of model refinement, scholars Zhang Aling, Zheng Huai, and He Jiankun from Tsinghua University proposed a 3E model suitable for China's national conditions in 2002. They adjusted the 3E model originally applicable to market economy in developed countries, considered China's statistical system and current situation [3], and developed a 3E system adapted to China's sustainable development needs, which laid a certain foundation for the following research of the coordination of domestic regions. After this, the scholar Zhao Fang measured the coordination degree of China's 3E

DOI: 10.54254/2754-1169/3/2022746

system with the help of principal component analysis (PCA) and fuzzy membership function [4] and designed the 3E model with specific quantification, which made China's 3E model more specific and detailed. To address the impact of population on the 3E system, four scholars, including Jiang Tao and Yuan, established a multi-objective optimal planning model for sustainable development based on the dynamic input-output principle on the basis of qualitative analysis to study the interrelationships between various economic factor changes and economic structural transformation, and development strategies and goals. They analyzed and simulated the medium- and long-term sustainable development in China [5], laying a foundation for the development of the 3E model to four dimensions.

2.2. New Human Capital Theory

The new human capital theory is a framework that encompasses factors ranging from endowments to the acquired environment and to individual development. The new competency-based human capital theory is used to explain the causes of and correlations between individual choices (educational attainment level, health, etc.) and outcomes (occupational choices, employment, and wages, etc.), and to explain the diversity and inequality of individual development. New human capital components include elements of competence (cognitive and non-cognitive skills), skills (education or on-the-job training), and health (physical health and mental health), with competence being the central concept in the theory [6].

Today, more than sixty years after the human capital theory was proposed, scholars gradually recognize the inadequacy of the traditional human resource theory in terms of its perspectives and reflect on and discuss it. Professor Wang Rong suggested that for the past fifty years or so, the discussion of public education in economics had been dominated by theoretical schools that adhere to the functionalist tradition, especially the human capital theory. To date, the academic rationale for the policy and social claims that the state should prioritize education, that education can promote economic growth, and that education can change social equity has been mostly provided by scholars of human capital theory at the global level. Scholars Li Xiaoman and Zeng Xiangquan provided a more detailed explanation of the new human capital theory, suggesting that the core of the new human resources is competence. In 2020, Professor Wang Rong once again proposed "rethinking after ten years" for the new human capital theory, affirming that human beings cannot be calculated in terms of the mere labor force and that education economics should be established, which should break the historical limitations of the human capital theory.

3. The 3E model based on a population perspective

The population has a non-negligible impact on the three subsystems of environment, economy, and energy in the 3E model, and this paper discusses the relationship and impact between population and each subsystem based on the new human capital theory.

3.1. Population - Environment

The exploration of the environment in this paper is divided into two main aspects – environmental problems and environmental capacity. In the following parts, this paper explains the links that exist between population and the environment in terms of both population and environmental capacity and population and environmental problems.

First, from the perspective of population and environmental capacity:

Dynamically, over a period of time, population growth will exceed the level of natural resources. If mankind does not recognize the finiteness of natural resources, not only will the natural environment and resources be destroyed, but also the population will be reduced in catastrophic forms,

DOI: 10.54254/2754-1169/3/2022746

such as famine, war, pestilence, etc. Natural resources are absolutely scarce and will not be changed by technological progress and social development [7]. When mass population shifts from less developed regions to developed cities, it will lead to the expansion of large cities and rapid growth of future energy demand, which in turn will cause an increase in urban carbon emissions and spatial shift of air pollution [8]

Tian Xueyuan pointed out the doctrines of "economic optimum population" for maximum economic efficiency and "power optimum population" for maximum national strength. From the basic standpoint, these optimum population studies are mainly limited to the quantitative aspect of the population, and domestic studies are also basically limited to the quantitative category. He put forward the theory of "all-round optimum population", which breaks through the boundary of population quantity and is defined as "a population whose quantity is appropriate, whose quality is steadily improving, and whose structure is relatively reasonable in relation to the resources, environment, economy, and social development under certain historical conditions, that is, a population that can promote the coordinated development of population and other development factors" [9]. According to this definition, the basic point of the strategy of sustainable population development in the world and in China today is to continue to control population growth, improve population quality, and adjust population structure, implementing a combination of "control", "improvement", and "adjustment". "The current strategy focuses on quantitative control.

Professor Meadows has developed an analytical model of system dynamics based on the five major factors affecting human survival and development – population, capital, food, resources, and the environment. These five factors interact with each other, and population growth plays a pivotal role. Population growth requires more food supply, which leads to resource depletion and environmental degradation, and proposes a relationship between environmental and population factors: environmental impact = population × wealth × technology [10]. The significance of this theory is that it reminds human society that the natural environment cannot support unlimited economic growth with existing production methods under current technological conditions. Population growth and consumption must be taken into account.

From the perspective of population and environmental problems:

In the relationship between human beings and the environment, human beings are both the root cause of ecological damage and an important force in building an ecological environment. According to Guo, the economic process must be included in the theoretical research of population, resources, and environment, and the economic process is the center linking population, resources, and environment [11]. Emphasis is placed on the impact of productive consumption on resources and the environment, and the transformation of economic growth is of great importance to both economic development and the solution to population, resource, and environmental problems.

By exploring the spatial and temporal characteristics of the coupled population-economy-environment system coordination in nine provinces of the Yellow River Basin from 2007-2018, Song Jie demonstrated that there is significant variability in the influence of the population subsystem on the coupled coordination of the Yellow River Basin system. Population size and population structure have a negative relationship with the degree of coupled coordination of the Yellow River Basin system [12]. Along with the growth of population, there has exerted greater pressure on economic development and environmental protection at the Yellow River Basin.

Population growth and rising consumption levels have caused human consumption of resources to greatly exceed the rate of population growth. While meeting the rapidly growing needs of mankind, production and domestic wastes have proliferated, placing increasing pressure on the environment.

DOI: 10.54254/2754-1169/3/2022746

3.2. Population-Economy

The impact of population on the economy is felt in all its aspects, both in terms of the value of human resources as embodied in the population itself and in terms of the impact of changes brought about by population movements, which have a significant impact on the regional economy in various forms. This paper discusses both the population itself and population flow.

3.2.1 From a human capital perspective

Endogenous growth theory suggests that there is an intertwined and endogenous relationship between population and economic development [13]. As an important driver of economic growth, the redistribution of population among regions has a profound impact on the rate of regional economic growth as well as on the mode of growth. At the same time, disparities in the level of economic development between regions can lead to spontaneous readjustments in the distribution of population.

In addition, human capital has a more significant impact on the development of industrial structures and the use of energy. This view has also been verified by the model of scholars Lu Jin, Liu Junqi, and Zhang Xiaodong. They used a finite mixture model to prove that the increase of human capital and the share of the working population helps to improve energy efficiency and the promotion of economic growth by upgrading industrial structure, and both of them are more helpful to play the economic growth effect of upgrading industrial structure.

3.2.2 From a population mobility perspective

Guifen Shi and Zhen Li verified the sample data of the Yangtze River Delta from 2005-2017 in the influence of population flow-on economic development in their study as a way to examine the specific impact of population flow-on economic development in the Yangtze River Delta. The study found that the population inflow in the Yangtze River Delta grows significantly and has a significant positive spillover effect on economic growth. The population inflow changes the demographic pattern of the Yangtze River Delta, promotes the accumulation of human capital, plays an optimal role in industrial structure, and can also promote scientific and technological innovation and residential consumption. It is verified that population inflow has a direct and positive effect on economic growth.

The same kind of study was also carried out by their colleagues Gu Songnan and Wan Xieqiu, who selected the empirical data of 31 Chinese provinces from 1998-2018 and examined the effect of population flow on China's economic development from a non-linear threshold perspective. This research also concluded that moderate population mobility can promote local economic development through the labor force transmission mechanism, but excessive population mobility can bring negative influence to social development and weaken the role of the labor transmission mechanism in promoting economic development. On this basis, they made recommendations to guide population mobility in a moderate and reasonable manner [14].

Population flow reflects changes in the spatial structure of the economy. As factors of production accumulate in different geographic scales, the efficiency of the spatial allocation of the regional economy is reflected in the impact of population flow, the strength of environmental management, and other economic factors on changes in the industrial structure. In addition, population migration and flow are also factors that influence the changes in China's population distribution and thus the overall spatial development pattern, reflecting the dynamics of population and economic and social development. Although the migration and movement of large numbers of people bring about various intertwined positive and negative effects on the development of outflow and inflow areas, it is generally dominated by positive ones [15]. What is certain is that a people-centred approach, in line with the objective trend of migration and mobility, can create a better economic and social environment for human development.

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3.3. Population-Energy

As the gross product increases, the demand for energy in production processes becomes greater. As the population grows, more people will own energy-consuming products, which inevitably leads to an increase in energy demand. In theory, as population increases and industrial modernization progresses, human demand for energy increases. The greater the population density is, the greater the amount of energy consumed will be [16]. The higher the population is, the more energy intensity is used for indispensable domestic energy consumption such as daily electricity, natural gas, and coal for cooking and heating. Given the higher daily energy consumption due to population growth, there is a positive impact on energy intensity.

Chen, Li, and Tan defined the population size effect and population density effect to illustrate the impact that the population makes directly or indirectly on energy consumption. On the one hand, more and more people are migrating from rural to urban areas, which will significantly increase the population size and population density. Such a population explosion will generate high demand for logistics services and consume more energy while promoting the economic growth of logistics. This effect is defined as the population size effect [17].

In addition, an increase in population density may have a scale effect, which will promote economic growth and reduce energy consumption. However, excessive population density may slow down the operational efficiency of logistics, indicating that economic growth consumes more energy. This effect is defined as the population density effect.

With the increase in the level of urbanization, a large number of farmers have entered towns and cities, where the population has increased sharply, leading to an increase in demand for various materials and infrastructure. There is a linear relationship between urbanization and carbon emissions, with urbanization leading to an increase in carbon emissions. At the same time, production has shifted from the original man-made products to the use of machinery, and consumption patterns have become high-carbon, directly leading to increased energy consumption and carbon emissions.

Both population density and human capital affect the productivity of cities [18], and agglomeration economies can significantly contribute to economic growth [19]. Thus, population plays an important role in regional development and energy consumption.

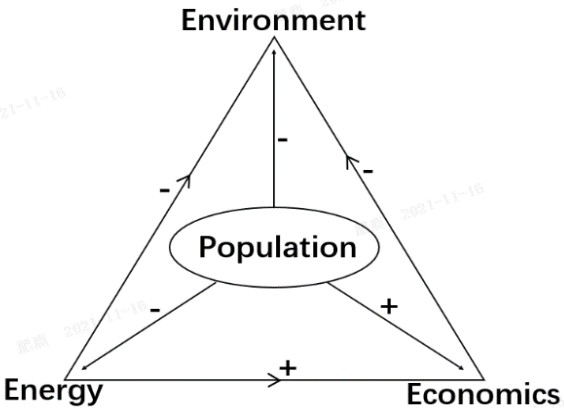

Figure 1: Effect of population on 3E system

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4. Discussion

Based on the above discussion, it can be seen that the population has a multifaceted impact on the 3E system. In this paper, the discussion of the impact of population on the 3E system is mainly from two perspectives: population quantity and population quality. The discussion of the environmental subsystem and energy subsystem mainly starts from the population quantity and discusses that the increase of population quantity brings negative effects on the environment, and the larger population brings greater environmental pressure. In the schematic diagram, "+" is used to represent the facilitating effect, and "-" represents the negative effect, which simply indicates the influential relationship that exists between the subsystems. As shown in Figure 1, the impact of population on the environment is "-". In the discussion of the economic subsystem, an increase in population means an increase in the labour force, which facilitates the economic subsystem in terms of both population size and population quality, so it is represented by "+" in figure 1.

The diagram shows that the other subsystems, namely the population subsystem, the economic subsystem, and the energy subsystem, all have a "-" impact on the environmental subsystem, that is, a negative impact. From the perspective of systematical research, in today's social environment where population and economy are growing rapidly and energy is continuously being exploited, the environment should be destroyed and declined at a rate commensurate with the development. The exploitation of energy, the surge of population beyond the capacity of the environment, and other factors will lead to a certain degree of environmental damage and deterioration, and fall into the vicious circle of more development and more destruction. However, people's green consciousness has been stimulated and cultivated, and the ecological civilization concept of conforming to nature and protecting the environment has effectively slowed down the rate of environmental deterioration due to the widespread attention to environmental protection.

In addition, innovation is another important factor in slowing down the rate of environmental decline, and technological innovation itself has certain energy-saving and emission reduction effects [20]. This study discusses the impact of population on the 3E system based on the new human capital theory, which focuses on the study of the quality of the population. The theory suggests that the more capable people are, the higher the value created, and one important manifestation of this is innovation [21]. Innovative green technology is an important technological guarantee for the development of a green economy and further environmental protection and ecological construction. The data prove that promoting technological innovation in enterprises and further improving the environment testing system is an effective way to achieve innovative development and green development at the same time [22]. In the dimension of subsystems, the improvement of population quality in the population subsystem can directly lead to the improvement of innovative technology, which indirectly has a positive effect on the environmental subsystem and greatly protects the environment. Therefore, even under the theory where all the effects on the environmental subsystem shown in Figure 1 are "-", that is, negative, the actual situation of the environment can still decline at a slower rate than in the theory.

5. Conclusion

Under the rapid social development at present, the coordination between energy, economy, and environment is not only beneficial to the progress of society, but also has great significance to the protection of the ecological environment, so the coordination degree between each system of energy, economy, and environment is widely discussed. In the background of the gradual maturity of 3E system, this paper mainly proposes the optimization of the composition of the 3E system model. It argues that population should be considered when calculating the degree of coordination of 3E systems. Based on the new human capital theory, the paper discusses the impact of population on each subsystem of the 3E system from three dimensions: population-environment, population-

DOI: 10.54254/2754-1169/3/2022746

economy, and population-energy. In the population dimension, the impact of population on each subsystem in the 3E system is further discussed in terms of both population quantity and population quality. The main contribution of this paper is to provide ideas for the optimization of the 3E system based on the new human capital theory. It adds "population" as an influencing factor, so that the study of the 3E system is closer to the real situation, and the research results and recommendations are more feasible.

The limitations of this paper exist in 2 main aspects.

1. This paper only discusses the impact of population on the 3E system, suggesting that demographic factors should be added to the study of 3E system coordination, but no research has been done on the measurement of refined coordination.

2. The amount of research on the relevant literature is rather limited and the discussion perspective of the population is not comprehensive.

In conclusion, the above discussion suggests that future research in related areas could be conducted in two ways.

1. A more comprehensive refinement of the 3E system model will make the 3E system more feasible for practical application based on theoretical research.

2. The calculation of the degree of coordination could be further refined by discussing the measurement of system coordination with the addition of the "population" factor.

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