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Comprehensive Impact Assessment Model of Petroleum Development on Economic, Environmental and Petroleum Resources

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Environmental accounting is of great practical significance for ecological development and economic development. The purpose of this study is to explore the comprehensive impact of petroleum development on economy, environment and petroleum resources. To this end, taking the research case of petroleum resource development as the object of study, this paper analyses the relationship between petroleum resources value and environment cost, and then constructs a comprehensive impact assessment model. The results prove that this model can display the real situation of economic development, which is conductive to understanding the economic development system under the background of petroleum development.

1. Introduction

The accounting system of national economic account designed by the United Nations Statistics Division (UNSD) has been widely recognized, but the coordinated relations between environmental resources and economic system development hasn’t been included. In other words, the GDP indicator that reflects economic development cannot clearly show the impact of economic development on the ecological environment.
For this, a comprehensive impact assessment model is constructed in this study, which shall provide a theoretical basis for the formulation and implementation of decision-making in the economic accounting system.

2. Literature review

Energy is an important material basis for the survival and development of human society. Social production and people's lives are inseparable from the consumption of various energy sources (Falkner, 2014). With the rapid economic growth, energy consumption is increasing, and the threats to the environment are gradually increasing. According to the statistics of the World Energy Statistics Yearbook of June 2018, oil is one of the main one-time energy sources. In 2017, global oil consumption increased by 1.8%, that is, 1.7 million barrels per day. For the third consecutive year, it has exceeded the average growth rate of ten years (1.2%). Growth has been the strongest in the past five years. While bringing economic development and social progress, the massive consumption of oil has also brought about problems such as depletion of petroleum resources, environmental pollution and ecological damage. From the perspective of future development trends, how to coordinate the issues between economic development, energy security and environmental protection will become an important issue for human society.
Energy, the economy and the environment have formed a new system, which is called the 3E system. Therefore, it can be used to study the dynamic relationship between 3E systems. Today, with environmental damage and energy depletion, economic development becomes critical. There is a complex and comprehensive interaction between the economy, the environment and energy. The operational mechanisms of the energy, environment and economic model (3E) and their key factors are the inherent part of dealing with this problem. Zhang et al. selected the annual data from 1970 to 2009 to establish a VEC model. The impulse response function and analysis of variance were used to analyze the short-term dynamic relationship of the 3E system. It was found that there is at least one cointegration relationship between 3E systems (Zhang et al.,

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2013). Shen and Mo regard energy, economy and environment as a system. According to the system coupling theory, a system coupling model of energy, economy and environment was established. The coupling relationship is analyzed. The model reflects trends in the interaction of each of the two subsystems, which helps to explore the underlying relationships and predict the development of the system (Shen and Mo, 2014). Wang et al. proposed coordination indicators and comprehensive assessment models for EEE (energy, economic and environmental) systems and used them for case studies in Shandong Province. The results show that there is a clear positive correlation between the energy system and the economic system. Economic development requires strong energy support. However, due to energy consumption, the environment is deteriorating. Therefore, high energy consumption, rapid economic development and low environmental quality occur simultaneously (Wang et al., 2014). To assess economic performance, Dong et al. extended the life cycle 2E (energy and environment) assessment to the 3E (energy, environmental, and economic) model. Later, the Multi-Criteria Decision (MCDM) approach was improved to integrate the 3E factor. In addition, a two-step weighting factor analysis was added. The robustness of the model was tested. Different preferences from different stakeholder groups can also be used. This new 3E model was then used for comparison of different MSW processing techniques (Dong et al., 2014). Pao et al. used the Lotka-Volterra model to study the competitive interaction between energy, environment and economy (3Es) in the United States. The proposed LV-COMSUD (sustainable Lotka-Volterra competition model) has satisfactory model fitting performance. A useful multivariate framework is provided to predict the outcomes associated with these interactions. Pure competition between emissions and GDP (gross domestic product), neutrality between renewable energy and fossil energy/nuclear energy, and the symbiotic relationship between GDP and renewable/fossil energy and between nuclear energy and fossil energy/emissions were discovered (Pao et al., 2015). A new so-called modeling approach was proposed to generate alternatives. Near-cost optimal solution space for global energy, environmental, and economic models was explored. The goal is to find the largest different global energy system transformation path. The degree of diversity of its approximated optimal region was assessed (Sueyoshi and Wang, 2014). In order to balance the relationship between energy use strategies and total energy consumption and the economy and the environment, Feng et al. proposed a single target and multi-standard optimization method that can be effectively formulated to fully utilize the energy delivered to the production process. Recommendations for energy supply operations based on optimization results are obtained. Finally, according to the optimization results, the cost of money increased by 35% in energy-oriented operations. In an economy-oriented operation, megawatt-hours of energy supply takes more than 17% time and tends to rely more on cheaper renewable energy (Feng et al., 2016). Fu et al. developed an inaccurate multi-objective programming model for regional economy-energy-environment system management to obtain an absolutely “optimal” solution. In the two comparative scenarios, three subsystems, six industries, four energy sources and three air pollutions were considered in the optimization model, and net system benefits and trade-offs between subsystems were analyzed. Interval parameter planning and multi-objective programming methods are incorporated into the model to address uncertainty and complexity in case studies. The results show that the model can provide an effective link between economic-energy-environment systems and provide decision makers with insights into the trade-offs of existing management policies (Fu et al., 2017). Wu and Ning combined the system dynamics model with the geographic information system to analyze the energy-environment-economic system of time and space. The economic, energy, and environmental interactions and the impact of key influencing factors are clearly addressed (Wu and Ning, 2018).

In summary, in order to maintain sustainable development, a suitable economic-energy-environment model needs to be established. It provides accurate guidance for the adjustment of social development management policies. Although the national economic account accounting system designed by the United Nations Statistics Office has been widely recognized, the coordination system between environmental resources and economic system development has not been noticed in the accounting system. In other words, the GDP indicator that reflects economic development does not clearly show the impact of economic development on the ecological environment. Therefore, in order to clarify this goal, a comprehensive impact assessment model was constructed. In the economic accounting system, this provides a theoretical basis for the formulation and implementation of decision-making.

3. Methods

3.1 System of environmental and economic accounting (SEEA) theory

Good environmental quality and conditions are the basis for sustained economic development. Natural environment plays a role in absorbing waste generated by economic activities, while transporting abundant resources to human economic activities. When natural resources are scarce and the environment capacity and self-purification ability cannot keep up with the degree of pollution, it will limit the development of the economy and bring certain obstacles to the sustainability of economic development. Therefore, the environment and the economy constitute an organic whole that is both interrelated and interacted on each other. The virtuous cycle of material between the environmental system and the economic system plays a key role in the sustainable development of the economy, and this virtuous cycle is based on the virtuous cycle and ecological balance of the environmental system. The economic development based on the virtuous cycle of environmental systems is not an infinite demand for nature, but a limited development under the premise of protecting the environment. It requires rational distribution, reasonable development and utilization of resources, and properly organize product structure so as to prevent pollution, reduce and even avoid environmental hazards. The essence of integrated environmental and economic accounting is to organically integrate the information about environmental resource use and exhaustion that is not included in the traditional way, to help understand the contribution of human activities to environmental degradation and resource depletion. By deducting this part of cost from GDP, it can more realistically reflect whether the development of society is sustainable, and ultimately provide more comprehensive information for the formulation of scientific resources development and environmental protection policies. The basic framework of SEEA is shown in Table 1.

Table 1: Basic framework of SEEA

Project	Economic activity	Natural assets
Supply	P	-
Economic use	CFC	-
Fixed capital consumption	NDP	-
Assets change	-	-
Inventory assets	-	-

Figure.1 shows the accounting system.

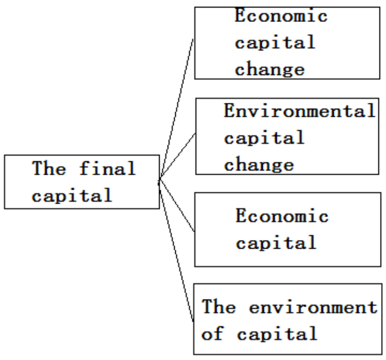

Figure 1 : Comprehensive environmental economic accounting system

3.2 Establishment of the environmental economic account

The establishment of environmental economic account is shown in Fig.2.

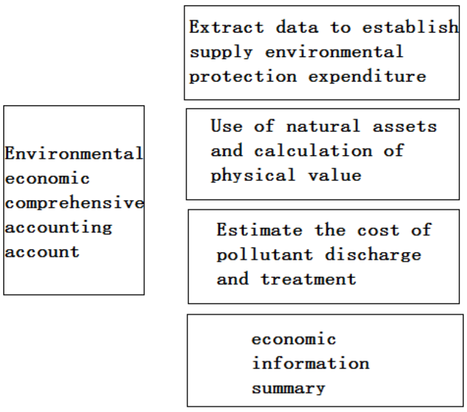

Figure 2: Environmental economic account

The data in the environmental economic account can only be used as the basic information of environmental policy, because the information of the environmental economic account may not be sufficient to form the final environmental policy. However, changes in environmental data of the account also have a significant correlation to economic growth, thus providing a basis for policy makers to formulate environmental policies that adapt to economic growth, e.g., in the petroleum industry the pollution discharge account and the environmental maintenance cost account reflect the relevant environmental governance efforts of the year, and when they are linked with the corresponding environmental protection expenditure data, the technology input cost can be compared with the actual environmental expenditure to estimate the financial needs to be considered when developing environmental policies by environmental protection department.

3.3 Comprehensive account characteristics

Since the industries involved in accounting are only limited to the oil development industry (mainly mining and smelting industry), there is no need to carry out statistical calculations for other industries. It's divided into four categories, as shown in Fig.3.

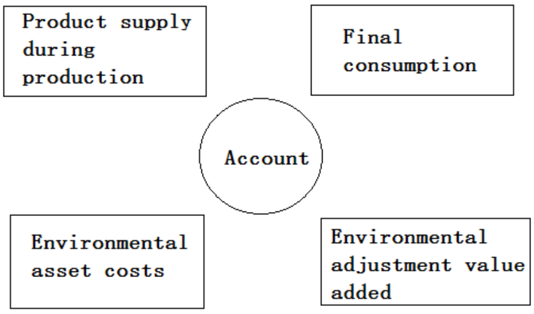

Figure 3: Integrated account design

It should be noted that this account belongs to a value account, without the opening stock, the ending stock, and the change. The opening and ending stocks have been already reflected in the natural asset account, and other changes have no impact on the adjusted comprehensive indicators due to the lack of data, so these three aren't included in the account. Changes in the flow of environmental assets are reflected in quality changes of environmental media and bioregions (actual environmental degradation) caused by emissions from production and consumption activities, but the reasons are derived from a variety of factors, and it's difficult to calculate and count directly the pollutants and the caused quality changes. The type of pollutant is shown in Fig.4.

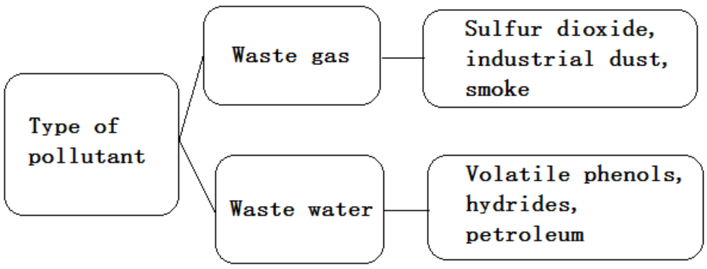

Figure 4: Type of pollutant

3.4 Integrated environmental and economic account

There are two main categories of value assessment methods for environmental function degradation: cost-based technology and damage-based technology. In the cost-based technology, the cost avoidance method is more commonly used, esp., its virtual disposal cost approach has been applied to calculate the maintenance cost of environmental asset mentioned above. The virtual disposal cost approach is to assume that all pollutants emitted into the environment are treated, and regard the cost required for virtual disposal as the value of environmental degradation. Then, by comparing the virtual disposal cost with the actual governance/treatment cost, the degree of governance and input level of the environment directly affected by the petroleum industry is measured, which thus provides the auxiliary decision-making information for the direction and intensity of environmental protection expenditure. According to the environmental protection payment account and the environmental asset maintenance cost account, the virtual disposal cost is larger than the actual governance cost, and the difference between them is the cost required for reaching the most conservative loss of environmental degradation. Finally, the ratio of the cost to the difference in the prevention and control of three main pollutants, as well as the ratio of the cost and the difference between the oil extraction industry and the petroleum smelting industry are compared to obtain the results.

4. Results and analysis

At present, the economic compensation system for such resources and ecological environment is not perfect. From the results of comprehensive environmental and economic accounting, oil exploitation has brought huge economic losses. In the Yellow River Delta, the depletion of petroleum resources accounts for a high proportion of the added value in its industry. So, it is necessary to incorporate this loss into the economic compensation system in order to achieve sustainable development of the resource economy and to “green” the development of the petroleum industry economy. It can be further explained from the four aspects of Fig.5.

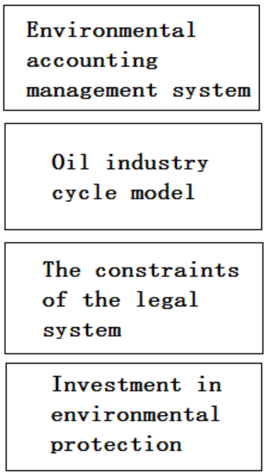

Figure 5: Oil development proposal

GDP is one accounting vertex in this paper. It’s also the environmentally adjusted value added and the final result of the green economy accounting, which are implemented on the basis of each sub-account established above, including the accountings of added value in the petroleum industry, resource value exhaustion, physical quantities of pollutants, environmental degradation costs, and environmental protection costs. The oil development industry is gradually improving its environmental sustainability when a steady increase in its output value is guaranteed. The green indicator reflects the real development of the economy. Currently GDP is one of the most important comprehensive indicators for evaluating development, but it’s more beneficial for economic development in terms of sustainability to pursue a higher green EGDP by losing part of GDP. It’s also necessary for the environmental adjustment and analysis of specific resource value depletion costs and virtual disposal costs.

5. Conclusions

Since the beginning of humanity, it has never stopped exploiting the natural resources. With the population, demands, and social development increasing, environmental pollution and ecological damage have become more serious since the middle and late centuries, which has caused the people to re-examine the relationship between humans and nature. Therefore, sustainable development has become a new concept of human development. A good ecological environment and a benign economic development complement each other. The blind exploitation of natural resources can only bring about temporary development of the economy, and undermine the development path of harmonious coexistence between man and nature. As the basic scientific theory for the implementation of sustainable development strategy, ecological economics comprehensively considers the relationship between economy, ecological environment and resources. It is also the scientific basis for regional ecological economic system research before making scientific decisions about the environment. Incorporating the environmental factors into the SEEA of national economic accounting has become a basic step and an important way to promote sustainable development.

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