



Ecological accounting and evaluation of urban economy: Taking Beijing city as the case

Xi Ji

School of Economics, Peking University, Beijing 100871, China

ARTICLE INFO

Article history:

Received 19 September 2009

Received in revised form 28 May 2010

Accepted 30 May 2010

Available online 4 June 2010

Keywords:

Accounting

Urban economy

Ecological economics

Embodied cosmic exergy

ABSTRACT

Urban economy is confronted with increasing biophysical limitations derived from the exhaustion of natural resources and the depletion of environmental capacity, and human cultural diversity has been declining during the fast urbanization. The conventional anthropocentric economics, regarding the natural environment as the 'exterior' of human economy, is invalid in the scientific evaluation on the contribution of natural resources and environment as well as human culture when facing the current urban crises. The theory of embodied cosmic exergy, as the latest development of ecological economics and ecological thermodynamics, is introduced in this study to construct an ecological evaluation framework of urban economy. The advantage of embodied cosmic exergy dedicated to ecological economics has been discussed in comparison with other ecological evaluation alternatives. Transformities describing hierarchies and manifesting quality are systematically calculated and tabulated. A new framework of embodied cosmic exergy based on network accounting (EmexNA) is sketched out in this study, taking not only diversity flows but also ecological stocks into consideration. The stock based concept of 'ecological wealth' and the flow based concept of 'ecological cost' as well as related evaluation indicators are developed based on EmexNA. Taking Beijing city as the case, the network accounting and related ecological evaluation of a practical urban economy are carried out in this study in the light of the basic social, economic and environmental data available from 1990 to 2005 of Beijing. The system construction and the ecological mechanism of the development of Beijing economy are correspondingly illuminated and discussed.

© 2010 Elsevier B.V. All rights reserved.

1. Introduction

1.1. Alternatives of ecological evaluation

Urban economy is facing increasing ecological crises of natural resources shortage, environmental deterioration and culture decline in its marvelous growth and expansion.

As a typical complex system with multiple hierarchies, urban ecological–economic system can be regarded as consisting of five parts including the natural primary production sector, the natural–economic production sector (i.e. the suburb agricultural production sector), the main urban production sector (including commerce, industry, urban consumers, and so forth), the population production sector, and the culture and information production sector. The industry-based urban production adds to the accumulation of material, energy, information, capital and population fluxes, while accelerates the downfall of natural resources and urban culture. As a heterotrophic and open thermodynamic system originally rooted in

E-mail address: jixi@pku.edu.cn

the broad natural environment, cities are confronted with increasing biophysical limitations derived from the natural resources depletion and environmental deterioration during their marvelous economic growth [1]. The destruction of cultural diversity becomes increasingly intense in the process of modern industrial revolution based on the huge consumption of fossil fuels.

Under the conventional economic framework, natural environment is regarded as the 'exterior' of the main urban economy and money circulates mainly in the urban production sector and partially in the natural-economic production sector. That is, money is mainly paid to people while natural resources and environmental capacity are usually used for free or undervalued [2]. The quality of population, in terms of the possessed knowledge and talents, owns the largest amplifier control effect on urban economy, which is usually ignored in the conventional evaluation framework due to the difficulties in objective quantification. Culture and information production including the generation and maintenance of human cultural diversity and genetic biodiversity is one of the important features of urban economy. A large part of the control over urban economy is realized through information, while due to the replicability, money is always only paid for the cost of the information carriers (including the embodied human labor) rather than the information itself.

The anthropocentric economic logic is invalid in scientific evaluation on the contribution of natural environment [3–6] as well as the culture and information, and then inefficient in response to the urban ecological crises. As one of the most creative ecological economists, Odum realized the intrinsic limitation of the neoclassical economics in evaluating natural services, and the viewpoint that internalization of externalities is also facing the obstacles of scientific and objective pricing of natural services. He brought forward a biophysical paradigm of ecological economics which insists on placing the natural factors and the culture and information factors of the complex ecological-economic system on the same platform with the social and economic factors, rather than regarding them as the 'exterior' of main economy, and he recommended the solar emergy instead of money as the evaluating basis [4]. Solar emergy, that is the embodied solar energy, is the total amount of solar energy used up in the transformations directly and indirectly to make a product or service [7]. As one of the landmarks of the new era of ecological economics, emergy method brings forward a new framework to comprehend the structure of the ecological-economic world and to understand the biophysical foundation of the human economy, and attaches importance to the contribution of the natural services to human economy. Emergy based evaluation and analyses are accordingly carried out widely in ecological, social and economic areas [8–15], and especially in urban ecosystems [16–21].

However, emergy is a concept based on energy. In the light of the first law of thermodynamics, energy is never used up. Therefore, double accounting is unavoidable in emergy synthesis. In addition, energy based concept fails to describe the thermodynamic quality, thus is incapable to measure the real depletion from a thermodynamic point of view. Odum came to realize this trouble and began to stress the concept of available energy, that is, exergy. Unfortunately, the time left for him was not long enough to completely accomplish the work on the fundamental transition from energy accounting to exergy accounting for ecological evaluation [6].

As an essential concept to embody the second law, exergy is the measure of the availability of energy. To steer a practical process along a definite direction, exergy, as the 'real power' for society, is always consumed due to the irreversibility [22]. As the extension of exergy based analysis, cumulative exergy is proposed by Szargut et al. [23–25], which is calculated as the sum of exergy among all chains associated with fabrications of products, and has been broadly applied [26,27]. However, focusing only on the consumption of non-renewable resources such as fossil fuels and ores, cumulative exergy based analysis ignores the multiple hierarchies of the ecosystem and neglects the life-support services from broad natural environment, and thus is inefficient in realistic portrait of the overall cost.

1.2. Embodied cosmic exergy based evaluation

As a generalization of cumulative exergy method, embodied exergy is proposed by Chen in place of embodied energy to define Odum's emergy [6]. Parallely, embodied cosmic exergy is proposed to construct a biophysical evaluation paradigm instead of solar emergy, and concrete calculation schemes based on embodied exergy are provided by Chen as a systematic revision and rephrasing of existing emergy accounting and evaluation. Cosmic exergy is defined as the maximum work that the thermodynamic system of earth can perform when the thermodynamic equilibrium is achieved between solar radiation as a hot thermal reservoir and cosmic background as a cold thermal reservoir [6,28]. Embodied cosmic exergy refers to the cosmic exergy consumed directly or indirectly in making or sustaining a general commodity as a product, service or an emission.

As the latest development of ecological economics, the theory of embodied cosmic exergy proves that cosmic exergy, due to the radiational difference between the sun and the cosmic background, instead of solar energy, is the primary driving force of the earth system to revitalize the metrological system, feed the hydrological system, renovate the biosphere and make all other natural and anthropogenic phenomena possible, by a global exergy balance of the thermodynamic system of the earth by Chen [28]. As the real wealth of the ecosphere and the human society, cosmic exergy is proved as the real scarcity related to the scale of human activities. According to the systematic study on the global consumption of the cosmic exergy in the earth and a budget of the exergy consumption with respect to main terrestrial processes, only 45TW cosmic exergy corresponding to 4100TW as terrestrial exergy is available to impel the main terrestrial processes, which accounts only for 0.025% of the total solar radiation entering the earth system. Among the 4100TW terrestrial exergy, only very little amount is available for human activities, such as the cosmic exergy obtained by the plants via primary production. Among the exergy

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات