Ocean Engineering 137 (2017) 1–12

Contents lists available at ScienceDirect

Ocean Engineering

journal homepage: www.elsevier.com/locate/oceaneng

Analyzing the decoupling relationship between marine economic growth and marine pollution in China

Jiandong Chen[a], Yun Wang[a], Malin Song[b,*], Ruocheng Zhao[c]

[a] School of Public Finance and Taxation, Southwestern University of Finance and Economics, Chengdu 611300, China
[b] School of Statistics and Applied Mathematics, Anhui University of Finance and Economics, Bengbu 233030, China
[c] Birkbeck College, University of London, London WC1E 7HX, UK

ARTICLE INFO

Keywords:
Marine economic growth
Marine pollution
Environmental Kuznets Curve model
Tapio elasticity coefficient method

ABSTRACT

This study analyzes the "quantity" and "speed" decoupling relationship between marine pollution and economic growth in China from 2002 to 2013. The results show that, when the red-tide disaster areas by coastal region is used as marine pollution indicator, an inverted N-shaped relationship is observed between pollution and growth. However, this curve fluctuates slightly, and its shape is more similar to monotonic decreasing. There are three states of "speed" decoupling between each marine pollution and economic growth indicator. The decoupling state between pollution and the economy changes rapidly, the deterioration of marine pollution being rather frequent. In some years, the pressure on the marine environment aggravated dramatically. Having combined both analyses, the study determines that marine economic growth and pollution in China have not been entirely decoupled in recent years, and that environmental pressure on marine economic growth remains obvious.

1. Introduction

Oceans occupy 71% of the earth's total surface area and contain diverse natural treasures. The significance of oceans is more apparent, since land resources have become increasingly limited. Due to the inherent advantage of possessing the world's fourth-longest coastline, China's marine economy has become increasingly prominent in its overall economic growth (*China Marine Environment Bulletin*, 2013). Since the 1990s, China's gross ocean product (GOP) has mostly maintained a two-digit growth rate annually, and total GOP has increased significantly. In 2014, the GOP reached CNH 5993.6 billion, accounting for 9.4% of China's gross domestic product (GDP), and 16% of the total GDP of the 11 coastal provinces. The growth rate of the GOP significantly exceeded that of the GDP during 2014 (China Marine Economic Statistics Bulletin, 2014). At the same time, the State Oceanic Administration of China (2013) predicts that, under normal conditions, the GOP in China will exceed CNH 20 trillion by 2030, and the proportion of GOP to GDP is expected to exceed 15%. Recently, along with China's economic growth into a "medium-speed" level, marine economy, as a new avenue for economic growth, has become of great significance to China.

As commonly known, China is not the only country that benefits from its marine economic activities. Several studies focus on the marine economy, and its impact on the national economy has been well established in developed countries. Since 1974, when the U.S. Bureau of Economic Analysis first proposed the concept of GOP, scholars have continued to undertake research on the marine industry in developed countries such as the U.S.(Colgan, 2007; Kildow and Colgan, 2005; Kildow et al., 2009; Pontecorvo, 1988), Canada (Mandale et al., 2000; Pinfold, 2009), the United Kingdom (Pugh and Skinner, 2002; Pugh, 2008), Australia (Allen Consulting, 2004), and France (Kalaydjian, 2008). These early results have affirmed the significant role of marine economic activities in national economic wealth creation and employment support, and ascertained the influence of the marine economy on the country development.

However, due to the extensive focus on marine economy, researchers (Costanza et al., 1999; Kildow et al., 2009) realized that the traditional assessment method of marine economic value has been unable to meet the requirements of sustainable development. Because adverse effects are not noticed immediately and are out of sight (Ofiara, 2015), it is difficult to gauge the environmental impact of the externality of marine economic activities. The impact of the marine economy on the marine environment could be attributed to frequently occurring human activities, such as overfishing, overflow due to oil and gas exploitation, coastal ecosystem damage, land-based sources of pollution, and ocean climate change (Antunes and Santos, 1999;

* Corresponding author.
E-mail address: songmartin@163.com (M. Song).

http://dx.doi.org/10.1016/j.oceaneng.2017.03.038
Received 17 September 2016; Received in revised form 25 January 2017; Accepted 17 March 2017

Byrnes et al., 2016). The ocean ecosystem is deeply influenced by unsustainable human activities (Halpern et al., 2008). Specifically, in the recent decades, changes in technology and industry have greatly accelerated the human ability to obtain ocean resources, and also the impact on the oceanic environment. This eventually modifies the ocean ecosystem through pollution, destruction of habitats, and invasion of exotic species (IPCC, 2007). Mostofa et al. (2013) summarized the key problems in marine ecosystems caused by increasing demand from human activities and the effect of global warming. Marine ecological damage caused by marine economic activities, such as ocean warming and ocean acidification, will in turn affect the healthy development of the economy and the lifestyle of the local population (Herr et al., 2009; Novo-Corti et al., 2015). Besides, with the influence of institutional theory being increasingly prominent in the research of enterprise strategic management, studies focus on how the marine industries' environmental and social performance changed under the influence of regulatory (coercive) pressures (e.g., Eide et al., 2009; Lu and Koufteros, 2014, Wuisan et al., 2012). According to institutional theory, it is inappropriate to measure the sustainable development of the marine economy only by output value. The importance of achieving social legitimacy and the reflections of economy and environment under the implementation of green manufacturing should also be taken into account (Dubey et al., 2015; Svensson and Wagner, 2015). At present, whether the economic and environmental impacts of green manufacturing taken by marine enterprises can achieve a win-win situation requires further study. Against this background, several scholars and institutions began to advocate the establishment of a marine economy with the sustainable development of the ecological environment and its broad prospects (Jane, 2009). Consequently, research on the relationship between the marine economy and environment became extensive. Some studies (Ofiara, 2001; Ofiara and Seneca, 2006) started to incorporate the marine economy and ecological environment quality of the coastal areas in one system to assess the quality of marine economic growth and relevant policies from a more comprehensive perspective, becoming a popular avenue in marine economics research. Marine economic development in China also increased the marine environment pressure caused by the rapid expansion of the economic scale. Meanwhile, the impact of regulatory pressures on the economy and environment remains to be analyzed. Therefore, exploring the evolution trend of the relationship between the growth of China's marine economy and its marine pollution is also a practical reference for implementing and estimating a policy of oceanic sustainable development.

Although developing an ecological and sustainable marine economy has been widely proposed and the analysis of the relationship between China's marine environment and marine economic growth has also intensified, most research is still limited to theoretical deduction. Studies using quantitative analysis to address this problem are very few (Wang, 2013; Talluri et al., 2016). Specifically, Qin and Tang (2009) used econometric methods to analyze the existence of the marine environmental Kuznets curve (EKC) in China, but with insignificant results. Wang et al. (2014) built a panel data model based on the EKC model, and concluded that the overall trend of the economy and environment in coastal areas in China from 2001 to 2010 exhibited an N-shaped relationship. Xu and Wang (2013) empirically analyzed the coordination degree between the marine environment and marine economy in China by using the entropy change equation, and found that, in most cases, there is no coordinated relationship between them. Based on the Tapio decoupling model and application of the decoupling index, Chen and Li (2015) assessed temporal and spatial variation trends in the decoupling states between Chinese marine economic growth and marine environmental pressure from 2002 to 2010, finding three states of decoupling between each environmental and economic indicator with different variation trends. According to previous research findings, study conclusions are different even when using the same method. To some extent, without considering the different results of the model analysis caused by the selection of indicators, using only a single quantitative method is neither comprehensive nor convincing. On one hand, the objectives of the different methods are diverse. Some aim at the specific number of changes, others at the relative amount of changes over a period. Combining different methods can avoid a one-sided conclusion and the results are complementary to a certain extent. On the other hand, the results of the measurement will eventually serve as control policy guidance. However, some methods may misjudge the turning point from "dilemma" to "double wins," which will mislead us into implementing the control strategy inefficaciously (Sheng et al., 2015). Currently, the relationship between the marine environment and marine economy is complicated, and can vary by sea area. However, there is a lack of specific analysis and prediction on the stages of different sea areas in China. Accordingly, to fill the gaps in current research, this paper analyzes the relationship between marine environmental pollution and economic growth by combining the EKC model and the Tapio elasticity coefficient method.

The main contributions of this paper are as follows. First, it builds regression models with quadratic and cubic terms based on the EKC model to analyze the "quantity" decoupling relationship between the marine economy and pollution from 2002 to 2013. Second, it introduces the Tapio elasticity coefficient analysis method to analyze the evolution of the "speed" decoupling states between the marine economy and pollution in coastal regions of China. Finally, it integrates the conclusions of the two decoupling methods into the study of the relationship between marine economy and environment, and successfully overcomes the shortcomings of using a single method.

The rest of this paper is organized as follows. In the next section, we review the theories underpinning our research. Section 3 introduces the two methods used. Section 4, based on the decoupling method, analyzes the decoupling relationship between the marine environment and economy based on relevant data. Section 5 follows a discussion of the findings and their theoretical implications. The paper also concludes with a summary of findings, limitations, and directions for future research.

2. Theory

First, it is necessary to review both theoretical and empirical works on economic growth and environment, which underpin our study.

2.1. Theoretical research: economic growth and the environment

Since the 1950s, the world economy shifted from the post-war recovery stage into a development period. However, the environmental crisis triggered by the rapid economic development, industrialization, and urbanization in western countries was ignored. There have been several serious environmental pollution incidents at this stage, which shocked the world as a result of the high level of economic development, through a series of environmental problems earlier highlighted in developed countries. Hence, the theoretical research focused on economic growth and environment was mainly conducted by western scholars.

In the beginning of the discussion, the concern was whether economic growth has limits. In 1972, economists (Meadows et al., 1972) from the Roman Club published a report, titled *The Limits to Growth*. Based on 1900–1970 data, the report presented a dynamic model focusing on five variables that influence economic growth: world population, industrialization, pollution, food production, and resource depletion. The authors intended to explore the possibility of a sustainable feedback pattern achieved by altering growth trends among the five variables under three scenarios (Victor and Rosenbluth, 2008). This report created a debate on the problem of limits of economic growth, creating two different attitudes among scholars: pessimism (Daly, 1977; Myrdal, 1974) and optimism (Ayres, 1997; Cleveland and Ruth, 1997). However, whether the limits of economic growth are