Reprint of: Quantifying direct and indirect carbon dioxide emissions of the Chinese tourism industry

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ABSTRACT

Under the background of greenhouse gases emission reduction, the measurement of carbon emissions from the tourism industry has attracted increasing academic attention. Tourism is not a traditional sector in the System of National Accounts, and as a result the statistics of carbon dioxide emissions of the tourism industry on a national scale is difficult to calculate. The measurement methodology of a bottom-up approach and a top-down approach were mainly used in others studies. Utilizing a boundary that includes domestic tourism consumption, inbound tourism consumption, and tourism consumption incurring domestically in relation to outbound travel and airfares paid to the national carriers, a top-down approach is used to measure the national tourism dioxide emissions combining the Tourism Satellite Account and the Input−Output model from productive industry. Using this case study, it was calculated that the total carbon emissions of the Chinese tourism industry in 2002, 2005, 2007 and 2010 were 111.49 Mt, 141.88 Mt, 169.76 Mt and 208.4 Mt respectively, accounting for 2.489%, 2.425%, 2.439% and 2.447% respectively of the total carbon emission of all industries in China. The indirect carbon emissions by other tourism sectors except the transport sector were 3−4 times their direct carbon emissions. Compared with the manufacturing industry, the tourism industry is an industry of low pollution and low energy consumption. We discuss the advantage and shortcoming of the two approaches and put forward some suggestions to assist the research of tourism carbon emissions.

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1. Introduction

The global climate change, with climate warming as the main characteristic, has already become a severe challenge facing the human race in the 21st century and the tourism activities of human beings are closely related to climate changes (Nicholls, 2006), Since the 1990s, the energy and environmental problems brought by tourism have attracted wide attention from the related organizations and scholars. In 1995, the 21st Convention of the Tourism and Travel Industry proposed that resource management and energy consumption are the key fields in the development of tourism industry (WTTC et al., 1995). Since then, some scholars have researched the connection between energy utilization and tourism

destinations, the energy consumed and the carbon emitted during the travelling process of tourists (Tamirisa et al., 1997; Schafer and Victor, 1999). In 2000, Gössling S. was the first to propose a method to systematically measure the carbon emission of the tourism industry (Gössling, 2000). Since then, this subject has been drawing increasing attention from academic circles and scholars made breakthroughs regarding the research methods in respect to the energy consumption and carbon emission figures of the tourism industry. Gössling S. and his partners proposed a research method to systematically analyze the energy consumption and carbon emission of the tourism industry, and develop systematic research over multiple aspects, such as: the ecologic efficiency of the tourism industry, voluntary carbon offset of air travel, carbon neutral tourism destinations, tourism food management, measurement of regional tourism carbon emissions, etc. (Gössling, 2002, 2009, 2013; Gössling et al., 2005, 2007, 2011). Becken and his partner did a research series on the energy consumption and carbon emissions of the tourism industry from multiple perspectives,

including tourist lodges, tourist resorts and activities, air travel, tourism transportation methods, etc., and proposed that the calculation of carbon emissions of the tourism industry is a key process to realize sustainable tourism (Becken et al., 2001, 2003; Becken, 2002, 2013; Becken and Simmons, 2002; Becken and Patterson, 2006). Later, scholars implemented wide studies on the energy consumption and carbon emissions of tourism and service industries in various countries and regions, and many representative figures emerged, such as Scott, Gössling S., Becken, Peeters, etc. (Becken, 2013; Cainelli and Mazzanti, 2013).

In 2008, the UNWTO and other organizations released the research report "*Climate Change and Tourism Industry: Coping the Global Climate Challenge*" (UNWTO et al., 2008). In 2009, the World Travel Tourism Council set the goal of cutting the carbon emission of the tourism industry by 25–30% by 2020 and 50% by 2035 compared to the base figures of 2005 (WTTC, 2009).

Compared with foreign countries, the research about the energy consumption and carbon emissions of the tourism industry in China has had a rather late start. In 2008, research appeared regarding tourism route products and carbon emission in tourism resorts (Li et al., 2008; Zhang, 2008). In 2009, energy use and carbon dioxide emissions of Penghu Island of China were quantified using life cycle assessment (Kuo and Chen, 2009). Especially after the Copenhagen Climate Conference (2009), scholars began to pay active attention to the means of low-carbon development of the tourism industry. The carbon dioxide emissions of the tourism industry of Chengdu are calculated based on the method introduced by the IPCC report from the Chengdu Domestic Tourist Expenditure Survey (Liu et al., 2011) and the energy consumption and CO_2 emissions from China's tourism sector in 2008 is estimated using a bottom-up approach (Wu and Shi, 2011). Tao and Huang (2014) reviewed the carbon dioxide emissions from tourism using different spatial scales. As for measurement theories and results of carbon emissions of the tourism industry, because the tourism industry is not a traditional part of the national economy account system, there is no country in the world that has a complete national statistical system for the energy demands or carbon emissions of the tourism industry, which has restrained the measurement of carbon emissions. Targeting the measurement of carbon emissions of tourism, existing research is mostly based on two theories: life cycle assessment and input–output, which essentially were to measure carbon emissions from the perspectives of "Consumption" and "Production" (Dwyer et al., 2010), respectively corresponding to the "bottom-up method" and "top-down method" (Filimonau et al., 2011; Becken and Patterson, 2006). In general, the bottom-up approach is best suited for small regions (Ya-Yen Sun, 2014), and the top-down approach is suited to tourism as a sector within a comprehensive national economic system. On a national scale, some research have been done in the last decades, but the cases are mainly in developed countries (Becken and Simmons, 2002, 2003; Perch-Nielsen et al., 2010; Dwyer et al., 2010; Jones, 2012; Konan and Chan, 2010; Minx et al., 2009) and there are no details of China using a top-down research method. Ya-Yen Sun (2014) presented the GHG studies carried out at a national level. It is important to note that in these studies, the system boundary, accounting caliber and measurement method is different. In regards to the top-down framework, most scholars support the Tourism Satellite Account and the Input–Output Model as a base. However, the research scope varies between them and some papers have not given clear calculation steps, making it very difficult for other scholars to reference in the future. According to the data contained in the statistical bulletin of the Chinese tourism industry, the number of Chinese inbound tourists in 2013 was 129 million persons, the number of Chinese domestic tourists reached 3.262 billion persons, and the total tourism income generated reached China Yuan (CNY) 2.95 trillion. Requirements were proposed for energy conservation and emission reductions of the tourism industry in both the "*Opinions of the State Council Regarding the Accelerated Development of Tourism Industry*" and the "*Instructive Opinions Regarding Further Promotion of the Energy Conservation and Emission Reduction Work of Tourism Industry*". To achieve carbon reductions, carbon emission measurements are the first step, however, the measurement of CO_2 emissions of the tourism industry in China is sorely lacking and there is great difference between the currently available calculation figures.

The first purpose of this study is to provide a comprehensive framework for a national tourism carbon dioxide account using the top-down method in accordance with Chinese National economic accounting system. The second purpose is to present a case study for China, where the total carbon emission of tourism industry in each sector are measured; including direct and indirect carbon emission using the Tourism Satellite Account (TSA) and the input–output model, which links to 23 different energy sources employed in China. This paper is structured as follows: Section 2 presents the boundary and the research framework for calculating the national tourism carbon dioxide emissions, Section 3 introduces data sources, Section 4 describes the empirical results and Section 5 presents the discussion and conclusions.

2. Methodology

2.1. System boundaries for tourism industry

Boundary defining has always been an important topic discussed by experts and scholars. Among the current research, most of them were from the perspective of tourists, and believed that the carbon emissions of the tourism industry are the carbon emissions directly generated by tourists in the tourism product life cycle from origin to destination and back to origin, and involving the links of meals, accommodation, travelling, sight-seeing, shopping, entertainment, etc., and excluding the indirect carbon emission generated from the production, manufacturing and distribution of the tourist physical carriers and those also generated by the tourism management authorities for the normal operations of the tourism industry, which is essentially carbon emission by tourists.

Currently, the tourism industry is absolutely not just an industry, but is more like a "Sector" that affects many industries. The tourism industry and the existing national economy sectors have all sorts of connections and influences. Therefore, this thesis believes that the carbon emissions of the tourism industry means the measured value of carbon dioxide equivalence directly and indirectly generated from the activity processes of the tourism industry, including the indirect carbon emission equivalence produced from the production, manufacturing and sales of tourism physical carriers and those generated by the tourism management authorities for the normal operation of the tourism industry.

Based on the scope of current Chinese statistic data, the scope of this research includes: a) domestic tourism consumption, b) inbound tourism consumption and c) tourism consumption incurring domestically in relation to outbound travel and airfare paid to the national carriers.

2.2. Research framework

The fundamental idea of this framework is to combine the TSA and IO models into a measurement of the tourism industry carbon dioxide emissions. In their study, Becken and Patterson (2006) applied both a bottom-up and a top-down method to estimate New Zealand's tourism carbon dioxide emissions. Here we follow the general idea of the top-down approaches and modify it