Energy 57 (2013) 427–433

Contents lists available at SciVerse ScienceDirect

Energy

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

Relating five bounded environmental problems to China's household consumption in 2011–2015

Lan-Cui Liu [a], Gang Wu [b,*]

[a] Center for Climate and Environmental Policy, Chinese Academy of Environmental Planning, Ministry of Environmental Protection of the People's Republic of China, Beijing 100012, China
[b] Institute of Policy and Management, Chinese Academy of Science, Beijing 100190, China

ARTICLE INFO

Article history:
Received 15 October 2012
Received in revised form
28 March 2013
Accepted 1 May 2013
Available online 25 June 2013

Keywords:
Household consumption
Environmental impact
Input–output approach

ABSTRACT

With the rapid development of industrialization and urbanization, China faces a number of serious environmental problems that significantly affect economic and social sustainable development. In this paper we quantify the CO_2, SO_2, NOx, COD (chemical oxygen demand) and ammonia–nitrogen emissions resulting from household consumption, based on an input–output model used to identify which consumption items appear mainly responsible for environmental impacts and which consumption items can lead to different environmental impacts in 2007. Using a 2007 input–output table, we found that CO_2, SO_2, COD, NOx, and ammonia–nitrogen emissions from household consumption in 2007 accounted for approximately 42.17%, 33.67%, 33.11%, 28.83% and 30.38% of China's total emissions, respectively. Each environmental impact arises from the consumption of a mix of goods and services. "Agriculture" and "Food and Tobacco Manufacture" consumption contributed more than 50% of COD and ammonia nitrogen emissions; "Electricity and Heating Generation" and "Food and Tobacco Manufacture" accounted for more than 50% of SO_2, NOx and CO_2 emissions. We classified consumption items into different types, with Type 1 and Type 3 countering each other, illustrating a trade-off between stimulating household consumption, mitigating COD and Ammonia nitrogen emissions and mitigating CO_2, SO_2 and NOx emissions.

1. Introduction

Now that China is experiencing rapid industrialization and urbanization, air pollution, water pollution, greenhouse gas emissions and other environmental problems are rampant. China's experience is much different from that of some developed countries whose environmental problems have occurred during the past 100–200 years. China's environmental problems pose a serious threat to the quality of life and the wellbeing of the country's present and future generations, and China faces a significant challenge in dealing with these problems. To avoid continued environmental deterioration and to improve the quality of the environment, China's government set bounded targets for emissions reductions of SO_2, COD, NOx, ammonia–nitrogen and the decline of CO_2 emissions intensity in its 12th Five-Year Plan (2011–2015).

China's current consumption patterns are likely largely responsible for its environmental problems. Consumption can lead to environmental degradation both directly and indirectly through purchasing and using goods and services to support consumer demand. A major part of consumption activities is determined in individual household, so most of the economy's environmental load can be allocated to households [1].

Households with different lifestyles demand different goods and services, resulting in varying types of environmental impacts, leading many studies to focus intensively on the environmental impacts of household consumption, and become one particular stream of sustainable consumption research [2]. Among these studies, we distinguish two types:

- Studies that focus on a single environmental problem arising from household consumption, such as CO_2 emissions [3–11] or water pollution [12]. These studies offer helpful suggestions to address specific environmental problems, but these suggestions may be unilateral and may worsen other environmental problems by shifting consumer choices in ways that have unforeseen consequences.

* Corresponding author. Institute of Policy and Management, Chinese Academy of Sciences, 15, Beiyitiao Alley, Zhongguancun, Haidian District, Beijing 100190, China. Tel.: +86 10 59358816; fax: +86 10 62327151.
E-mail addresses: wugmail@126.com, gangwu@seas.harvard.edu (G. Wu).

0360-5442/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.energy.2013.05.043

- Studies that analyze multiple environmental problems, like six types of greenhouse gases [13], or air and water pollutions including SO_2, NOx and BOD (Biological Oxygen Demand) etc. [14–19]. These studies can provide more comprehensive suggestions to cope with multiple environmental problems simultaneously and to establish sustainable consumption patterns.

Specifically, Sánchez-chóliz et al. analyze environmental impacts including three atmospheric pollutants (CO_2, SOx and NOx) and four indicators of water (waste water, nitrogen, metals and BOD) in the Spanish economy, and found that pollution in Spain was closely linked to food production, energy, extractive industries and paper manufacturing [14]. Roca and Serrano analyzed the relationship between income growth and nine atmospheric pollutants (CO_2, CH_4, N_2O, SF_6, HFCs, PFCs, SO_2, NOx and NH_3), and found that for all the pollutants, emissions increased monotonically with household expenditure, and no turning point was recorded [15]. Nansai et al. analyzed Japanese household consumption patterns to minimize each environmental burden, including CO_2, waste, NOx and COD, and found that the shift of Japanese consumption patterns toward minimizing CO_2 or NOx emissions within a mere 10% range relative to present levels led to reductions in all types of environmental burdens [16]. Kerkhof et al. evaluated the relationship between household expenditure and the environmental impact categories of climate change, acidification, eutrophication and smog formation in the Netherlands, and found that environmental impacts increase with increasing household expenditure [17]. Cellura et al. evaluated Italian households' air emissions, including emissions of CO_2, N_2O, CH_4, NOx, SOx, NH_3, CO, PM_{10} and NMVOC, and found that indirect emissions are the main source of pollutants, particularly with N_2O (approximately 91%), CH_4 (approximately 97%), SOx (approximately 95%) and NH_3 (approximately 96%) [18]. Cellura et al. used Structural Decomposition Analysis (SDA) to analyze the driving forces of changes in economic, energy and environmental indicators, and found that "agriculture", "hunting and sylviculture", and "road transportation" are the primary sectors affecting air emissions, and should be considered when attempting to reduce harmful environmental impacts [19]. Based on Kerkhof et al., studies in the Special Issue of the Journal of Industrial Ecology on Priorities for Environmental Product Policy analyzed the impacts of total societal consumption for a broad set of environmental impacts [17]. We reviewed the results of these studies and found that indirect impacts were usually higher than direct ones and that the final consumption categories of housing, transport, and food are associated with the bulk of environmental impacts in all categories. The studies mentioned are vital for identifying products and services with low environmental impacts and for guiding consumption volumes and patterns. However, they all focus on developed countries, with none of them focusing on China.

In this paper, integrating China's environmental targets in 2011–2015 with household consumption, we aim to examine the relationship between China's household consumption and multiple environmental impacts, including CO_2, SO_2, COD, NOx, and ammonia–nitrogen, and we identify which consumption items are likely responsible for environmental impacts and which consumption items can lead to different environmental impacts, in order to yield insights into the achievements of CO_2, SO_2, COD, NOx, and ammonia–nitrogen targets from a household consumption point of view. Compared with the existing related studies, our study is novel because, as far as we know, this is the first China-specific analysis of multiple environmental impacts of household consumption that integrates household consumption with the bounded targets for emissions reduction of SO_2, COD, NOx, and ammonia–nitrogen, along with the decline of CO_2 emissions intensity, during China's 12th Five-Year Plan.

The remainder of our study is organized as follows: In Section 2, we describe the input–output approach and our data sources. In Section 3, we present study findings, including the environmental impacts of rural and urban household consumption, and the indirect environmental impacts of households at different income levels. In Section 4, we discuss our conclusions.

2. Method and data

2.1. Input–output method extended to environmental impacts

Pollutant emissions via household consumption are measured by considering the sum of: a) indirect emissions arising from productive sectors and b) direct emissions caused by household consumers. Direct environmental impact refers to the impact that occurs as the consumer uses the product. For example, emissions released while driving a car. Indirect environmental impact is defined as the impact occurring during a product's production process or its waste treatment. The following equation calculates the total environmental impact of household consumption:

$$E = E^{\mathrm{d}} + E^{\mathrm{i}} \tag{1}$$

where E refers to total environmental impacts of household consumption, E^{d} refers to the direct environmental impacts of household consumption, and E^{i} refers to the indirect environmental impact of household consumption.

The calculation of direct and indirect carbon emissions of household consumption is demonstrated in Ref. [7].

(1) Direct SO_2 and NO_x emissions of household consumption

$$E^{\mathrm{d}} = \sum_i f_i \times E_i \tag{2}$$

where f_i refers to the emissions factor of SO_2 and NO_x of i energy use, E_i refers to the direct fossil fuel use of household, and i refers to the type of energy used.

The direct COD and ammonia–nitrogen emissions of household consumption were not included in this paper because there is no official statistical data.

(2) Indirect environmental impact of household consumption

Household consumption generates demand for goods and services. Production of goods and services, meanwhile, requires the direct use of inputs from various sectors, which in turn use inputs from other sectors (indirect use) in the various stages of the industrial process. Recognizing the direct and indirect demand generated between industries, some studies have used the input–output model as a systematic, standard method to develop studies related to environmental issues (energy consumptions [1,20,21], greenhouse gases [4,6,7,13,24], water [12], land use [22], pollution [15–19,23], etc.) and to support information-based environmental and economic policies.

We also use an input–output model to calculate the indirect environmental impacts. Indirect environmental impact of household consumption is the combined result of the environmental impact intensity and the volume and composition of household consumption.

The indirect environmental impact of household consumption is calculated with the following equation (3):

$$E^{\mathrm{i}} = \Omega(I - A)^{-1} y \tag{3}$$

where Ω refers to pollution emissions (SO_2, COD, NOx, and ammonia–nitrogen) by each sector to produce a monetary unit of