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Analysis

Lifestyles, technology and CO_2 emissions in China: A regional comparative analysis

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ABSTRACT

With rapid economic development, higher income levels, urbanization and other socio-economic drivers, people's lifestyles in China have changed remarkably over the last 50 years. This paper uses the *IPAT* model (where I = Impact representing CO_2 emissions, P = Population, A = Affluence, and T = emission intensity) to analyze how these main drivers contributed to the growth of CO_2 emissions over this time period. Affluence or lifestyle change has been variously recognized as one of the key factors contributing to CO_2 emissions. Through comparative analysis of the development of five regions in China, we trace lifestyle changes since the foundation of the People's Republic of China (PRC) in 1949 until 2002. We find that household consumption across the five regions follows similar trajectories, driven by changes in income and the increasing availability of goods and services, although significant differences still exist between and within regions due to differential policies in China and different possibilities for social mobility. There are considerable differences between the southeast and northwest and between urban and rural areas. We also found that technological improvements have not been able to fully compensate for the increase of emissions due to population growth and increasing wealth, which is also in line with results from other studies. Finally, this paper emphasizes that developing countries such as China, which is home to 22% of the world population and a growing middle class, and which is on a fast track to modernization, need to ensure that people's lifestyles are changing towards more sustainable ways of living. China has been investing heavily in infrastructure and thus creating the emissions of tomorrow. Thus investing, for example, in public transport and low energy building today will help reduce emissions in the future and will support more sustainable lifestyles.

1. Introduction

In China carbon dioxide emissions have shown an increasing trend over the last 50 years, particularly during the high economic growth periods of the last two decades (Guan et al., 2008, 2009). In 2003, carbon dioxide emissions in China accounted for 15.5% of the world's total (EIA, 2006), and China has become the largest CO_2 emitter in the world exceeding the emissions of the US in 2006 (Auffhammer and Carson, 2008). Similarly, the International Energy Agency (2006) reported that China's CO_2 emission intensity per GDP was 658.1 t per million dollars in 2003, which was 27.8% higher than the world average, and 41% higher than the EU average. In response the UN Climate Change Conference 2007 in Bali proposed that China, as a large emitting country, will be expected to take on future targets to mitigate Greenhouse Gases emissions (ERM, 2007). Since then, China has unveiled a climate change action plan but at the same time is stressing that it will not sacrifice economic ambitions to international demands to cut greenhouse gas emissions. Given its position as the world's largest emitter and one of the largest growing economies it plays a major role in any global effort (Brahic, 2007). Fig. 1 shows the trend of CO_2 emissions during the last five decades.

CO_2 emissions increased gradually from 1952 to 1962, did not change significantly between 1962 and 1965, and then more than tripled by 1978. There was a short break between 1978 and 1980, before China entered its rapid economic growth, with further increases of 150% between the beginning of the open door policy in 1978 and 2002. For each of these periods different drivers contributed to emissions.

A large number of studies investigating energy consumption and CO_2 emissions in China were carried out especially analyzing the more recent past (e.g. Auffhammer and Carson, 2008; Fisher-Vanden et al., 2004; Guan et al., 2008; Hubacek et al., 2007; IEA, 2007; Lin et al., 2008; Peters et al., 2007; Sinton and Levine, 1994). The aim of this paper is to investigate the driving forces of CO_2 emissions in China since 1952. We employ the Impact (CO_2) = Population × Affluence × Technology model to evaluate the significance of each factor contributing to CO_2 emissions. In Section 2 we give a brief overview of the development and usage of the *IPAT* model. Acknowledging the significant regional differences in China, we select five very divergent provinces as case studies, situated in the east (Shanghai), south (Guangdong), centre (Henan), north (Heilongjiang) and west (Gansu). These selected

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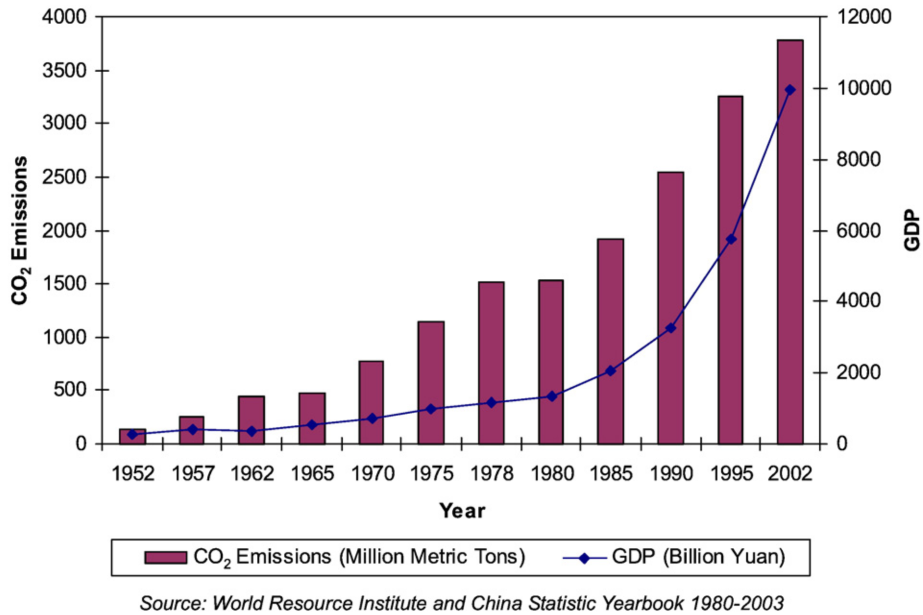

Fig. 1. China's CO_2 emissions and GDP from 1952–2002.

regions have very different attributes and development paths that make them interesting for this study: Shanghai is the most developed region in China with a very high population density. Guangdong is located in the southeastern coastal area and is a quickly developing and designated as special economic zone; it is very close to other southeastern Asian countries and has very close trading links to other economic growth centers. Henan has been a cultural and political center for the last thousand years, and also shows very high population density and economic growth (CZCRD, 2004); Heilongjiang is the most northern region of China, with significant structural changes in both agriculture and heavy industry; and finally Gansu is a typical rural province in western China with low economic growth and relatively low living standards. In Section 3, we apply the *IPAT* model to identify and analyze the main drivers (*P*, *A*, or *T*) for carbon dioxide emissions in these five provinces. In Section 4, we further analyze and compare these lifestyle changes through decomposition of consumption patterns into eight major consumption categories for these provinces from 1985 to 2002. We then compare them to Japan as a benchmark for a developed country and as an indicator of where China's lifestyles might be heading in the future (see Hubacek et al., 2007). The eight major consumption categories included in this study are food, clothes, household facilities, medicine and medical service, transportation and communication services, recreation, education and cultural services, residence, and miscellaneous items.

2. Review of the IPAT model

2.1. IPAT and its variations

The *Impact* = *Population* × *Affluence* × *Technology* or *IPAT* equation was developed in the early 1970s to further a debate between Paul Ehrlich and John Holdren, on one side, and Barry Commoner on the other side. The debate was concerned with which driver is the most important in contributing to environmental degradation (Commoner, 1972a, 1972b; Ehrlich and Holdren, 1972a, 1972b; Ehrlich and Ehrlich, 1990). The approach that was applied in this debate, the *IPAT* model, is based on index number calculations. A significant early contribution to this body of literature was made by Fisher (1922) who developed the well known Fisher index. Ang et al. (2004) extended the conventional two-factor Fisher index formula to the *n*-factor case, which provides a way of generalizing the earlier *IPAT* framework. The *IPAT* identity has been regarded as an easily understandable, widely utilized framework for analyzing the driving forces of environmental change (e.g. Chertow, 2001; Dietz and Rosa, 1994, 1997; Harrison, 1993; Hubacek et al., 2007; Raskin, 1995; York et al., 2002), but has also been criticized for some of its assumptions on the proportional relationship between factors and environmental indicators (York et al., 2003). One of the most relevant studies in the study context is the IPCC special report on emission scenarios which discussed the *IPAT* and the *Kaya* identity and their application to CO_2 emissions (IPCC, 2001). Ang and others have created a substantial amount of literature on index decomposition analysis for energy use and environmental emissions (e.g. Ang and Liu, 2001; Ang et al., 2004; Ang and Zhang, 2000). In recent years, much research has been done to further develop the IPAT framework by incorporating more factors into the equation (e.g. Waggoner and Ausubel, 2002) through further disaggregating technology (*T*). Rosa and Dietz (1998) reformulated the *IPAT* equation into a stochastic model, referred to as *STIRPAT* for Stochastic Impacts by Regression on Population, Affluence and Technology, which allows for non-proportional effects from the driving forces; this model had been applied to analyze the effects of driving forces on energy consumption and CO_2 emissions by York et al. (2003).

In this study we choose the IPAT model because it allows 1) to explicitly identify the relationship between the driving forces and environmental impacts; and 2) to show the impact as a result of the interaction of the driving forces through the multiplication of factors. In other words, the *IPAT* identity implies that no one factor can be held singularly responsible for environmental impacts (York et al., 2003).

2.2. Logarithmic IPAT

The IPAT method is simple, but appropriate for showing the main drivers of increasing CO_2 emissions in China. The amount of carbon dioxide emissions can be represented by an $I = PAT$ type decomposition Eq. (1)

$$I = P \cdot \frac{E}{P} \cdot \frac{I}{E} \tag{1}$$

Where I represents the amount of carbon dioxide emissions, P represents population, and E stands for private expenditure. Thus, $A = E/P$ is expenditure per person in yuan indicating affluence, and