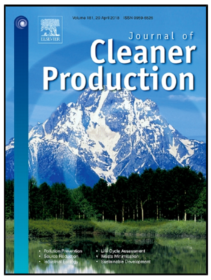
Accepted Manuscript



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PII:	S0959-6526(18)30609-7
DOI:	10.1016/j.jclepro.2018.02.277
Reference:	JCLP 12224
To appear in:	*Journal of Cleaner Production*
Received Date:	04 September 2017
Revised Date:	23 February 2018
Accepted Date:	25 February 2018

Please cite this article as: Jun Liu, Shaohui Zhang, Fabian Wagner, Exploring the driving forces of energy consumption and environmental pollution in China's cement industry at the provincial level, *Journal of Cleaner Production* (2018), doi: 10.1016/j.jclepro.2018.02.277

Exploring the driving forces of energy consumption and environmental pollution in China's cement industry at the provincial level

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Abstract: Identifying strategies for reducing energy consumption and environmental pollution in China's cement industry requires a comprehensive analysis of the sector on various scales, taking into account, in particular, the heterogeneity of abatement options. We develop a spatial and temporal decomposition analysis to quantitatively examine the driving forces of energy consumption and emissions of carbon dioxide (CO_2) and air pollutant emissions in China's cement industry at the national and provincial scales during the period 2005-2012. The results show that, nationally, due to the rapid growth of cement and clinker production, CO_2 emissions experienced a substantial increase. While the emissions of Sulphur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter (PM) were found to initially decrease (due to stringent air pollution standards), and then rose due to the increase of cement production. At the provincial level, we also observe that the developing regions (e.g. Anhui, Jiangsu, Shandong, and Sichuan) have a large share of total emissions of CO_2 and air pollutants, while the megacities of Beijing, Shanghai, and Tianjin contributed less to the total emissions. From spatial decomposition perspective, the energy intensity and emission factor affect CO_2 emissions largely but have a negative linear relationship primarily in developing regions. The findings in this study can directly be used to narrow down the projection of GHG mitigation and air pollution abatement on economic and technical perspectives and help policy maker to identify priority options for tackling the issues of global climate change and improve regional air quality.

Keywords: Chinese cement industry; spatial and temporal decomposition; energy consumption; CO_2 and air pollution; provincial scale

1. Introduction

Cement is the major component of concrete; its production currently requires massive amounts of raw materials such as limestone and non-renewable energy, and has harmful impacts on air quality and climate change. The global cement industry contributes 5-7% of global anthropogenic CO_2 emissions (Wang et al., 2013). China has been the largest cement producer in the world since 1985, accounting for ~ 60% of the global cement production in 2012 (Chen et al., 2015; Edwards, 2013; Zhang et al., 2015a). In recent years, China's cement industry has skyrocketed owing to accelerating economic development and urbanization. The Chinese cement production increased from 210 million ton (Mt) in 1990 to 2,210 Mt in 2012, expanding 10 times. Over the same period the associated energy consumption increased by a factor of seven approximately, as result of implementing various energy efficiency measures (National Development and Reform Commission of China, 2013). Several approaches have been used to estimate the factors/trajectories of energy consumption and emissions of CO_2 and air pollutants, as well as forecast the future potentials of energy efficiency improvement, CO_2 mitigation, and air pollution abatement in the Chinese Cement industry (Cai et al., 2016; Chen et al., 2015; Feiz et al., 2015; Ke et al., 2013; Lei et al., 2011; Liu et al., 2015; Wen et al., 2015). For example, Li et al., (2014) used life cycle inventory (LCI) to analyze the air and water pollution of China's cement industry and quantify the potential improvement of avoided environmental damages by using

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