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A bibliometric analysis on trends and characters of carbon emissions from transport sector

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ABSTRACT

Transport sector's substantial contribution to global greenhouse gas emissions has made it a growing area of study and concern. In order to identify trends and characteristics of carbon emissions research in the transportation sector we conducted a Bibexcel and complex network analysis for the period 1997–2016. In addition, we identify critical themes and contributions of research articles using *h-index*, PageRank and cluster analysis. We report contribution of countries, authors, institutions and journals, as well as performance of citations and keywords. Co-citing situations between different countries, authors, and institutions are also analyzed using network analysis. Between 1997 and 2016 we found a rise in publications on carbon emissions in the transportation sector and increased cooperation between countries, authors, and institutions. Authors from the USA, China and United Kingdom published the most articles and articles with the highest academic influence. Tsinghua University from China is the leading institution in carbon emissions research in the transportation sector. The most widely published author and cited author is Dr. He. We conclude our analysis by analyzing keywords and trends to suggest critical topic areas of future research. The systematic approach undertaken in this study can be extended and applied to other research topics and fields.

1. Introduction

The transportation sector accounts for 23% of global CO_2 emissions, the majority of which result from the burning of fossil fuels (Liu et al., 2015). The substantial contribution of the sector to global greenhouse gas emissions has made it a growing area of study and concern. Efforts to reduce carbon emissions will be further challenged by forecasts of 25% GDP growth in the transportation sector by the year 2030 (Liu et al., 2015; Timilsina and Shrestha, 2009).

The Kyoto protocol agreement brought political attention to reducing carbon emissions in the transportation sector as countries sought strategies to reduce their greenhouse gas emissions. In 1997, at the time of the Kyoto protocol agreement two-thirds of transportation related carbon emissions originated from the wealthiest 10% of countries (Hensher and Button, 2003). In the last 20 years, however, the distribution of emissions has changed with increasing emissions coming from developing countries with fast growing economies and rising household incomes. Carbon emissions from the transportation sector are projected to rise without

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substantial technological advancements and behavior changes. Reducing emissions from the transportation sector is critical to reach the Paris Agreement's goal of keeping global temperature rise below 2 degrees Celsius above pre-industrial levels.

Research on carbon emissions in the transportation sector have mainly focused on three key areas: trends and drivers of emissions; scenario analysis of future emissions; strategies to limit or reduce transportation related carbon emissions.

(1) Trends and drivers of carbon emissions in the transportation sector

Michaelis and Davidson reviewed greenhouse gas mitigation measures in the transportation sector, concluding that to reduce carbon emissions requires technological innovation to offset future growth. Policy changes alone, they argue, would not be adequate (Michaelis and Davidson, 1996). Chapman conducted a review of transport and climate change focusing primarily on approaches to reduce emissions from personal vehicles, road freight and aviation. The review found that adoption of energy efficient technologies requires behavior changes and policy support (Chapman, 2007). Lakshmanan and colleagues explored driving factors underlying transportation CO_2 emissions in the USA using decomposition analysis. Results of their analysis identified the three most important factors driving emissions to be growth in per capita vehicle kilometers travelled, population, and GDP (Lakshmanan and Han, 1997). Timilsina and colleagues explored rising transportation related CO_2 emissions in selected Asian countries between the years 1980 and 2005. The authors found that modal shift, increasing GDP per capita, fuel mix, and emission coefficients explained rising emission in the selected countries (Timilsina and Shrestha, 2009).

(2) Forecasting future transportation related emissions and scenario analysis

Hao and his colleagues developed a bottom-up model to simulate energy consumption and greenhouse gas emissions of China's passenger vehicle fleet under five different scenarios including constraining vehicle registration, reducing vehicle travel, strengthening fuel consumption rates, vehicle downsizing and promoting electric vehicle penetration. Implementing all five measures together, the authors found, would reduce fuel consumption by 37% by 2030 in comparison to the reference scenario (Hao et al., 2011). Karplus and his colleagues evaluated the impacts of Corporate Average Fuel Economy (CAFE) policy on transportation related carbon emissions in the USA over the period 2015 to 2030 (Karplus and Paltsev, 2012). The authors' analysis of implementing a 5% CAFE policy would reduce gasoline use by 25 billion gallons per year, reduce CO_2 emissions by 190 million metric tons per year and cost $25 billion per year relative to a no CAFE standard baseline.

(3) Strategies to limit or reduce transportation related carbon emissions

Research on strategies to reduce carbon emissions in the transportation sector have mainly focused on the adoption of alternative fuel sources with lower carbon content (Cuda et al., 2012; Kumarappan et al., 2011; Aryanpur and Shafiei, 2015) or the adoption of energy efficient technologies such as electric or fuel cell powered vehicles (Weiss et al., 2011; Pavlovic et al., 2016; Mohamed, 2016). Shiau and Michalek looked at optimal design and allocation vehicles to minimize life cycle greenhouse gas emissions (Shiau and Michalek, 2010). Krauss and his colleagues reviewed studies related with powertrain market penetration scenarios to optimize fleet composition see (Krause et al., 2030). They formulated Bayesian Belief Networks to predict how future technology and policy scenarios will influence market shares of different vehicle types. Bishop and his colleagues modelled contributions of vehicle downsizing, technology switching and changes in VKT necessary to determine an optimum UK passenger vehicle fleet composition to reduce greenhouse gas emissions (Bishop et al., 2016). Ehmke and his colleagues explored reducing the number and length of trips using personal vehicles, through changes in routing, modal shift and transport infrastructure (Ehmke et al., 2016).

The aforementioned studies highlight aspects of a rapidly growing body of research. No articles, however, have attempted to summarize scientific development based on bibliometric and network analyses to review this topic systematic in the existing literature databases. To fill this gap, we propose a systematic approach combining bibliometric and complex network analyzes to comprehensively review carbon emissions research in the transportation sector. Given the breadth of research on the topic, a systematic review will help researchers understand key developments and patterns in such a field over time, identify major contributions and contributors, and direct their research agendas. Systematic reviews differ from traditional narrative reviews by employing a replicable, scientific and transparent process that minimizes selection bias inherent in exhaustive literature searches (Vrabel, 2015). Using this unique approach, we identify trends and characteristics of carbon emissions research in the transportation sector from 1997 to 2016. Specifically, we identify thematic developments, contributions by country, institutions, authors and journals as well as cooperation between different countries, institutions, and authors. Based on the results we suggest several important areas of future research, particularly with the potential application of renewable and sustainable energy sources in the transportation sector. The rest of the paper is structured as follows: Section 2 describes data collection tools and methodological approaches; Section 3 presents results of the bibliometric and complex network analyzes; and, Section 4 summarizes key findings and highlights a research agenda forward.

2. Methodology, data collection and treatment

2.1. Methodology

We use a hybrid approach to systematically review research on carbon emissions in the transportation sector integrating