New energy vehicle in China for sustainable development: Analysis of success factors and strategic implications

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ABSTRACT

The purpose of this study is to understand the effects of the influential factors that affect the sustainable development of new energy vehicle in China, investigate the cause-effect relationships among them, and propose some appropriate policies and efficacious measures for the policy-makers to promote its sustainable development. Interpretative Structuring Modeling was used to identify the critical factors affecting the sustainability of China’s new energy vehicle industry and to find the potential relationships among the factors; subsequently, fuzzy Decision Making Trial and Evaluation Laboratory was employed to investigate the cause-effect relationships among the influential factors and to prioritize these factors. The results reveal that technological maturity, technological standards for new energy vehicles, and funds on R&D of new energy vehicles are the three most important driving factors for promoting the sustainable development of new energy vehicle industry of China. Some implications were also proposed for China’s authority. The success factors and strategic implications of new energy vehicles in China were investigated in a multi-criteria analysis approach.

1. Introduction

China has achieved a significant progress on economy which attracts worldwide attentions, and one of the most distant achievements is the double digit growth of gross domestic production (GDP) (Hong et al., 2013). However, this also leads to many problems, i.e. energy security problems (Ren and Sovacool, 2014a; Wu, 2014) and environmental contaminations (Jiang et al., 2010; Ren et al., 2015b). To detail these, China’s oil dependence rate reached 54.8% by the end of June 2011, the rate will contentiously grow in future, and almost 80% of the imported oil was transported from the Strait of Malacca as a strategic vulnerability of China which is a single chokepoint and has high risks for oil transportation (Zhang, 2011). The import rate of total consumed oil in China will reach to 76% by 2015 (BP, 2016). The greenhouse gas emission is the a severe typical environmental problem in China, the CO2 emissions of China increased rapidly at the speed of 6% from 1990 to 2006 and reached 5.65 billion tons in 2006, and finally surpassed U.S. and became the largest CO2 emitter (Hong et al., 2013; Jiang et al., 2010). The CO2 emissions in China account to 25% of the total emissions (IEA, 2015), thus, energy consumption and greenhouse gas emissions become two of the most important concerns of China’s authority.

The transport, especially passenger transport, has significant contribution to global energy consumption and greenhouse gas emissions (Zhou et al., 2013). Similarly in China, substantial increase of passenger and freight transport demand in China due to the rapid urbanization, industrialization, and burgeoning GDP has led to a sharply increase of energy consumption and greenhouse gas emissions in the past decades (He and Chen, 2013). Accordingly, energy-saving (especially refers saving fossil fuels) and emissions mitigation on national transport attracted more and more attentions from academic and China’s authority (Li et al., 2013a).
It was estimated that China’s private car ownership has reached 28.7 millions by 2007 which accounts for 66% of the total national civilian vehicles (Wang et al., 2013). There are 23.85 million new cars which were registered in China in 2015, and the car ownership reached 279 million (Xinhua News, 2016). The car ownership in China is very low, and there are only 25 cars per 1000 people in China whereas Europe has 600 cars per 1000 people, and the US has more than 700 cars per 1000 people. With the improvements of living standards of Chinese citizens, the demand of vehicles in China will continuously grow the future (Bambawale and Sovacool, 2011). It is apparent that large amount of energy consumption and greenhouse gas emissions due to transport are two severe problems in future of China. Thus, various measures and actions have been implemented to address these problems, i.e. developing public transport routes (Cao and Liang, 2012), fuel quality improvement, alternative fuels and advanced vehicles (Wu et al., 2010), and restricting the use of vehicles (Xiaoming et al., 2008), et al. Among these, the measure of developing advances vehicles, especially new energy vehicles has been regarded as one of the most promising scenarios for enhancing energy security, saving fossil fuels and alleviating greenhouse gas emissions (Gong et al., 2013; Liu and Kokko, 2013).

New energy vehicles refer to the four-wheel vehicles that use non-traditional fuels (bioethanol, liquid natural gas, biogas, and biodiesel), electric vehicles, battery electric vehicle, plug-in hybrid vehicle, and various hybrid types of these vehicles (Liu and Kokko, 2013). New energy vehicle industry has been received more and more attentions all over the world for its advantages of high potential for energy saving and emission mitigation (Cuma and Koroglu, 2015; Hannan et al., 2014; Li et al., 2014; Poullikkas, 2015; Raslavičius et al., 2015; Speidel and Bräunl, 2014). The development of new energy vehicle is the inevitable choice to China for achieving a low-carbon future, mitigating energy dependence, and completing economy transition (Yang et al., 2014). China has initiated new energy vehicles plans and projects (especially focusing on electric vehicles) since the late of 1990s, and China’s authority took the new energy vehicle industry as a good opportunity to overtake the developed countries in automotive industry for the small technology- and industry gap between China and the developed countries (Hu et al., 2010). There are also various types of new energy vehicles in China such as pure electric vehicle, fuel cell vehicle, natural gas vehicle, and biofuel vehicle (Luo and Zhang, 2012). Among these new energy vehicles, battery electric vehicle and plug-in hybrid electric vehicle are the most popular in China and both of them have promising development potentials for promoting China’s low-carbon transportation under the current conditions. The battery electric vehicle adopts electric motors and motor controllers rather than internal combustion engines for the propulsion of vehicle. The plug-in hybrid electric vehicle adopts the rechargeable batteries or some other energy storage device for propulsion, and these energy storage device can be recharged. However, China’s new vehicle industry faces not only opportunities, but also challenges and obstacles, i.e. technology maturity, consumer acceptability, standards and regulations, et al (Zhou et al., 2013; Xu, 2014). Accordingly, more and more studies have been carried out to analyze the status of China’s new vehicle industry and to propose some measures for promoting its development. For instance, Zhang and Hu (2013) used SWOT analysis to analyze the strengths, weaknesses, opportunities and threats of China’s new energy vehicle industry and provided some recommendations to enhance the competitiveness for the new energy automotive industry. Li et al. (2013b) investigated the existed problems in China’s new energy vehicle industry through a systematic analysis, and also proposed some measures for improving this industry. Yuan et al. (2015) presented a comprehensive and critical review of the policy framework for China’s new energy vehicle industry, analyzed significant challenges that hinder its development, and proposed some suggestions for future development. All these studies are beneficial to the stakeholders/decision-makers in China to take efficacious measures for promoting the development of new energy vehicle industry of China. However, it is also important to analyze the sustainability of new energy vehicle industry for a sustainable future. In order to fill this gap, this study aims at analyzing all the factors in economic, environmental, social-political, and technological aspects that influence the sustainability of China’s new energy vehicle (mainly refers to battery electric vehicle and plug-in hybrid electric vehicle) industry, investigating the cause-effect relationships among the influential factors, prioritizing these factors, and proposing some valuable implications for promoting the sustainable development of China’s new energy industry.

Besides the first part (Introduction), this study is organized as follows: Part 2 presents the methodology by applying it on China’s new energy vehicle industry, Interpretative Structuring Modeling has been used to identify the factors affecting the sustainability of China’s new energy vehicle industry and to find the potential relationships among the factors; subsequently, fuzzy Decision Making Trial and Evaluation Laboratory has been employed to investigate the cause-effect relationships among the influential factors and to prioritize these factors; then, the results have been discussed in details; according to the results, some implications have been proposed for China’s authority in Part 3; finally, this study has been concluded in Part 4.

2. Methodology

Interpretative Structuring Modeling (ISM) and fuzzy Decision Making Trial and Evaluation Laboratory (DEMATEL) were combined to investigate the success factors affecting China’s new energy vehicle industry and the complex relationships among these factors in this study. ISM was used to determine the influential factors and to identify the potential relationships among the influential factors, then, fuzzy DEMATEL was employed to investigate the cause-effect relationships among the influential factors and to prioritize these factors in terms of their relative importance on promoting the sustainable development of China’s new energy vehicle industry.

2.1. ISM for identifying potential relationships among the influential factors

Interpretative Structuring Modeling (ISM) can help the decision-makers to develop a map for describing the complex relationships among multiple factors involving in a complex situation through computer-aided learning process (Kannan et al., 2009). This methodology developed by Warfield in 1974 (Warfield, 1974a, 1974b) has been successfully and widely used for understanding the
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