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Business innovation and government regulation for the promotion of electric vehicle use: lessons from Shenzhen, China

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ABSTRACT

The deployment of electric vehicles has attracted growing attention and is now seen as a possible pathway for a transition towards sustainable transportation. This paper provides insight into the commercialization of electric vehicles in Shenzhen focusing on business innovation and the regulatory context in which it occurs. Using the business model canvas framework, this paper analyzes interactions between enterprises and governments along the value chain of electric vehicles in the bus and taxi fleets. It also discusses the strengths and weaknesses of the Shenzhen model both in business innovation and government regulation for promoting electric vehicle use. This paper finds that Shenzhen has succeeded in fostering a distinct government-enterprise cooperation model that not only reduces the financial pressure on the local government to promote electric vehicle use, but also gives enterprises significant leeway to experiment with various innovative business models. The joint result of these efforts is that the commercialization of electric vehicles has become feasible for delivering the public transport service (buses and taxis) in Shenzhen. Still, this paper argues that the current model of Shenzhen can be further enhanced by: 1) encouraging private investment in charging infrastructures by means of public–private-partnerships; and 2) standardizing electric-vehicle technologies and production to break down the local protectionism in the electric vehicle market. The Shenzhen model acts as a source of inspiration by pointing out the significance of integrating business innovations and government regulations to facilitate the deployment of electric vehicles, which provides practical lessons for industrial players and policy makers in other cities. Furthermore, this work offers theoretical references regarding the application of the multi-actor perspective and the business model canvas framework to analyze the actors and interactions along the value chain of innovative technologies.

1. Introduction

Escalating energy and environmental issues have brought the development of sustainable transport to the agenda of cities worldwide (Yigitcanlar et al., 2008). Recently, electric vehicles (EVs)[1] have been claimed to provide a pathway for the transition towards sustainable transportation in view of EVs' potential to solve energy and environmental problems (Steinhilber et al., 2013), although new problems such as battery waste might appear. In China, EV deployment is seen as a solution not only for mitigating the oil demand from the growing vehicle fleet, but also for improving poor air quality in mega cities (Huo et al., 2013). Beyond this, EVs may imply future environmental potential in reducing CO_2 emissions if they are combined with the extensive use of renewable energy source (RES) power (Ou et al., 2010; Huo et al., 2010). EVs can also facilitate the integration of RES into the electricity grid through providing energy storage services for the intermittent and fluctuating RES power (Lund and Kempton, 2008; Li and Lukszo, 2014). Additionally, in the Chinese context, embracing EVs offers many opportunities to renew the domestic automobile industry and promote economic development (Gao et al., 2008). However, in spite of positive societal effects, EV deployment still faces considerable social and technical barriers, such as immature battery technologies and range anxiety among EV users (Egbue and Long, 2012; Steinhilber et al., 2013; Lane and Potter, 2007).

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[1] EVs here are broadly defined as vehicles that need to be charged, including battery EVs (BEVs), plug-in hybrid EVs (HEVs) and fuel-cell EVs (FCEVs).

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Table 1
A brief review of China's policies, regulations and nationally funded programs for promoting EV development.

Time	Government agencies	Policies, regulations and programs
2001	MOST (Ministry of Science and Technology)	The 10th FYP 863 program started an EV-specific project (2002–2006) and set a budget of 140 million dollars for EV technologies research and development (Yang et al., 2013).
2006	MOST	1) The 11th FYP 863 key project (Zheng et al., 2012); 2) Listed the EV industry in the national medium and long-term science and technological development (2006–2020) (MIST, 2009).
2007	NDRC (National Development and Reform Commission)	Regulation of Access Management Rules for New Energy Vehicle Production (NDRC, 2007).
2009	NDRC, MOST, MIIT (Ministry of Industry and Information Technology), MOF (Ministry of Finance)	1) Plan to restructure and revitalize the auto industry and invest around 175 million dollars to promote the development of BEVs, HEVs and other EV-related components (NDRC, 2009); 2) Nationwide demonstration of energy-saving & new energy vehicles; 3) Rules for energy-saving automobile manufacturers and products.
2011	MOST	The 12th FYP special planning for EV development (2010–2015) aimed to advance key EV-related technologies, including batteries, electric motors, EV control system, and focus on the light BEVs over the next five years.
2012	State Council	The energy-saving and new energy vehicle development plan (2012–2020) (NEA, 2012).

As shown in Table 1, a series of policies has been issued by the Chinese government to boost EV R&D activities since the 9th Five-Year Planning (FYP) period (1996–2000) when EV was first put forward in the National Key Science & Technology Industrialization Projects (Gong et al., 2013). The favorable policies and financial incentives spurred on the progress of EV technology and production capability in China (Yang et al., 2013). Then EVs were successfully demonstrated during the Beijing Olympic Games (50 EVs) and Shanghai World Expo (120 EVs). In particular, the nationwide EV demonstration program known as "Thousands of Vehicles, Tens of Cities (TVTC)" is seen as China's first step in going from EV's laboratory stage to market deployment. This program was implemented with city-based pilots focusing on the use of EVs in public transport (Zheng et al., 2012).

Although the TVTC program has not reached the targets planned at the beginning, no one can deny its significance in gaining experience in exploring new solutions for deploying EVs in China. Many studies have been carried out on the progress and challenges of the pilot cities, such as (Zheng et al., 2012; Gong et al., 2013; Marquis et al., 2013). In particular, Marquis et al. (2013) state that various models for EV deployment have been established in the pilot cities depending on local conditions. Moreover, Weiller et al. analyze the business models for the commercialization of EVs in four places worldwide (Shenzhen, Hangzhou, California and Paris), focusing on partnerships between enterprises in EV purchasing and charging (Weiller et al., 2015). In general, the lack of business innovations has been identified as a key barrier for enterprises to deploy EVs in the real market (Bohnsack et al., 2014; Silvester et al., 2013). Instead, a government-dominated style of decision-making prevails in most pilot cities in China, which implies that the local governments who desire to fulfill the targets assigned by the central government are the real implementers of EV policies. In this sense, deploying EVs is not a market-driven technology diffusion, but a government-dominated political target.

Against this background, Shenzhen is distinguishing itself from other pilot cites in deploying EVs in a commercial way rather than by heavily relying on government interventions (Marquis et al., 2013). Shenzhen had deployed the largest number of EVs among all the cities by 2012 when the TVTC program was supposed to end. Moreover, Shenzhen expects to deploy more than 3000 BEVs in the taxi fleet and 7000 new energy vehicles[2] in the bus fleet by 2015 (Shenzhen DRC and Transport Commission, 2012). This not only makes Shenzhen one of the largest EV-penetrated cities in the world, but also helps Shenzhen earn much credit in the development of smart and low-carbon cities in China (CEM, EIA and IEA, 2013).

Therefore, this study aims to uncover the myth of Shenzhen regarding EV commercialization and gain lessons for other cities in EV deployment. This study focuses on business innovation and government regulation with regard to EV deployment, based on the logic that business innovation is crucial to capture the market value of emergent EV technologies (Christensen et al., 2012; Chesbrough, 2007; Boons and Lüdeke-Freund, 2013) and the government should be held accountable to creating a regulatory context to support such business innovations (Birkin et al., 2009; Steinhilber et al., 2013). More specifically, this paper will answer the following questions: 1) how do enterprises and the government interact in EV deployment in Shenzhen? 2) what strengths and weaknesses does Shenzhen have with regard to business innovation and government regulation? and 3) what recommendations can be proposed to fix the weaknesses? To answer these questions, this paper carries out a case study on the implementation of the electric-bus (E-bus) and electric-taxi (E-taxi) fleets in Shenzhen.

This paper is organized as follows. Section 2 presents the theoretical foundations of this paper. Section 3 briefly introduces the TVTC program that sets out the national background to EV deployment in Shenzhen city. Section 4 illustrates the interactions among enterprises and the government in the case of the E-bus and E-taxi fleets respectively. Section 5 discusses Shenzhen's strengths and weaknesses in business innovation and government regulation for EV deployment, and proposes recommendations for further improvement. The final conclusions are made in Section 6.

2. Theoretical foundations

2.1. Transition theories and innovation systems

Recently, transition theories have stood out in aiding analysts and policy-makers in interpreting and managing the transformation process of large socio-technical systems. In particular, transition theories have been applied to analyze the development of sustainable transport, such as in Kemp and Rotmans (2004), Geels (2012). Transition literature highlights that transitions consist of bunches of system innovations and they require multi-

[2] Based on the Chinese context, new energy vehicles include EVs and other non-conventional fuel-driven vehicles, such as liquefied natural gas-fired vehicles.

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