The death of a transport regime? The future of electric bicycles and transportation pathways for sustainable mobility in China

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ABSTRACT

This paper has an empirical and theoretical focus: to empirically assess electric bicycle development in China, and to theoretically test and apply the "Multi-Level Perspective" on transitions and innovation. We examine the electric bicycle (e-bike) sector in China to understand the future prospects for urban mobility and the interaction of e-bikes as a form of vernacular technology within the existing transport regime. For this purpose, we address the following questions: 1) What factors will influence the future adoption of e-bikes? 2) How are alternative travel modes evaluated against e-bikes? 3) Will e-bikes become a popular sustainable mobility mode in the future or only an intermediary mode to cars? To provide answers, we conducted a survey in Nanjing city in order to assess the attitude of e-bike users, and other mode users (e.g. pedestrians; bicycle users). We then analyse responses from this survey through the lens of sociotechnical transitions theory, notably the "Multi-Level Perspective" notions of niches, regimes, and landscape. The paper explores the influential factors underpinning future e-bike adoption and the decision-making calculus behind alternative mode choices. Generalised Linear Models are used to investigate the factors influencing future e-bike adoption and alternative mode choices based on the survey data. We conclude that e-bikes are an intermediary mode on Nanjing's motorisation pathway, and that they therefore may eventually reflect a dying regime.

1. Introduction

This paper investigates whether electric bicycles, a somewhat neglected but socially important mobility technology, are likely to be an enduring feature of future modal choice for urban transport in China. Drawing from the concept of socio-technical transitions (Geels, 2002), we aim to make empirical and theoretical contributions. Empirically, we ask: 1) What factors will influence the future adoption of e-bikes? 2) How are alternative travel modes evaluated against e-bikes? 3) Will e-bikes become a popular sustainable mobility mode in the future or only an intermediary mode to cars? And theoretically, we ask: 1) Are e-bikes an established or dying transport regime? Such questions require us to examine technologies through a range of possible pathways, and thereby to assess their interaction within "regimes", a term that encompasses a constellation of mutually reinforcing features that becomes the accepted nature of everyday life. These concepts have been applied to the realm of transport (Geels et al., 2012), and underpin the research reported in this paper. Household decisions on mobility choices have long been recognised as a key feature of urbanism in general (Dieleman et al., 2002; Hansen, 2015). Research has identified how urban

structures can give rise to certain mobility choices (Shirgaokar, 2015), but there has been less attention on how current and future mobility choices may enable or constrain urbanism typologies. Thus it is proposed here that the uptake of e-bikes in China is reflective of and contributory to a wider process of urban-rural drift (both permanent and temporary) in which such e-bikes may be more of a temporary expedient or "stepping stone" on the pathway to full (car-based) automobility rather than a laudable "green mobility" platform.

To provide some clarity, the term "electric bicycles" (e-bikes) is generally used to refer to two-wheel transport machines with an electric motor used to power the vehicle, or to assist with pedalling (SBQTS, 1999). Most e-bikes fall into three categories: bicycle style e-bikes (usually termed "Pedelecs" in Europe), scooter style e-bikes (e-scooters), and something in-between these termed a hybrid style. All e-bikes have three main components: Motors, rechargeable batteries, and controllers, which differentiate an e-bike from other alternative transport modes. Compared with traditional bicycles, e-bikes are faster and require less physical effort. Compared with motorcycles, e-bikes are lightweight and have no exhaust emissions. Compared with buses, e-bikes provide greater accessibility and flexibility of use. Compared with

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Nomenclature

ACI	acoustic complexity index
GLM	Generalised Linear Models
Pr($>$|t|)	*P*-value for that *t*-test
p-value	probability for a given statistical model
R^2	the coefficient of determination
Std. Error	standard error
VIF	variance inflation factor

cars, e-bikes are easy to operate, convenient to use, do not require a licence, more affordable, and easier to park. With these advantages, e-bikes have attracted an increasing number of users transferring from walking, bicycles, motorcycles, buses, and cars (Cherry and Cervero, 2007; Weinert et al., 2007; Xu et al., 2014; Zhang, 2011). *E*-bikes are highly embedded within the regime of mobility in China, being employed for both utility and leisure uses (Cherry and Cervero, 2007; Weinert et al., 2007; Zhang, 2011; Ye et al., 2014).

Although drawing from socio-technical transitions theory in which niches, regimes, and landscapes are dynamic and always in flux, we treat e-bikes in this paper as a "regime" in their own right, although such a regime also interacts with other regimes (and niches). We consider e-bikes a regime for at least two reasons. Firstly, the annual sales of e-bikes in China are about 30 million units (Jamerson and Benjamin, 2013), meaning they have established economies of scale and also their own supportive policies, stakeholder groups, and industry practices. Nowadays, > 220 million e-bikes are in use in China (Yang and Yang, 2016). The explosive growth of e-bikes has already attracted the attention of government, and also resulted in consequent supportive government regulations (Rose, 2012). Second, e-bike pathways are, consistent with MLP theory, contested, and generate friction. For instance, Chinese authorities argue that e-bikes cause numerous traffic accidents, and undermined urban road transportation rule compliance due to the traffic violation behaviour of e-bike users - such as running red lights, and overloading (Du et al., 2013; Lu et al., 2015; Wang et al., 2011). In addition, e-bikes have been restricted by some urban authorities because of potential lead pollution created by the use and disposal of lead-acid batteries (Chen et al., 2009). It is a concern that only 33% of lead-acid batteries were properly recycled by official companies in China, while 67% were illegally recycled in hazardous and polluting ways (Chun, 2013). The uncontrolled lead recycling process increases

the likelihood of a negative impact on human health, such as developmental disorders and a lower IQ (Sanders et al., 2009).

The paper is organised as follows. The following sections introduces the research methods and theoretical approach of the paper, research design, case and field procedures, and model speicification. Then, the survey results of the future choices of e-bikes users with respect to e-bikes and other alternative travel modes are discussed in Section 6. To further explore the mode choice behaviour. And the factors influencing future modal choices using the Generalised Linear Models (GLM). A further analysis is performed in Section 7. The final section presents the conclusions following the research as well as suggested areas for further development.

2. Research methods and approach

The conceptual framework employed in this study is rooted in the "multilevel perspective on innovation," or MLP, arising from innovation studies, evolutionary economics, and science and technology studies. This approach posits that cars and even electric forms of mobility create part of a socio-technical system, one that involves not only technological "artefacts" (such as the car) but broader social, cultural, economic, and political factors depicted in Fig. 1. This requires analysts to focus not only on infrastructure and technical systems, but human users and actors (and their behaviour) as well as the institutionalization of their behavioural patterns. The research reported in this paper relates to some, but not all, of the elements of Fig. 1. The paper has a focus on markets and user preferences, the artefact, and culture and symbolic meaning. It also touches upon infrastructure and regulation and policies. It does not relate to the production system, the maintenance system, or the fuel infrastructure.

As Geels (2012) indicates, the MLP moves beyond (and in a way, integrates) the conceptual tools utilized by neoclassical economics, psychology, ecology, and political science. Economics helps reveal market failures and the motivating factors of price and affordability; psychology helps reveal attitudes and behaviour of individuals whose aggregated choices result in social outcomes; ecology looks at environmental problems and some of the failures of capitalism. Political science often examines the struggles over policy implementation and the way that global norms interact with the local level in the form of regulations and policy programs.

Applying the MLP to analyse sustainable mobility can help understand the transport system and possible transition pathways towards more sustainable mobility (Geels et al., 2012). The MLP has been
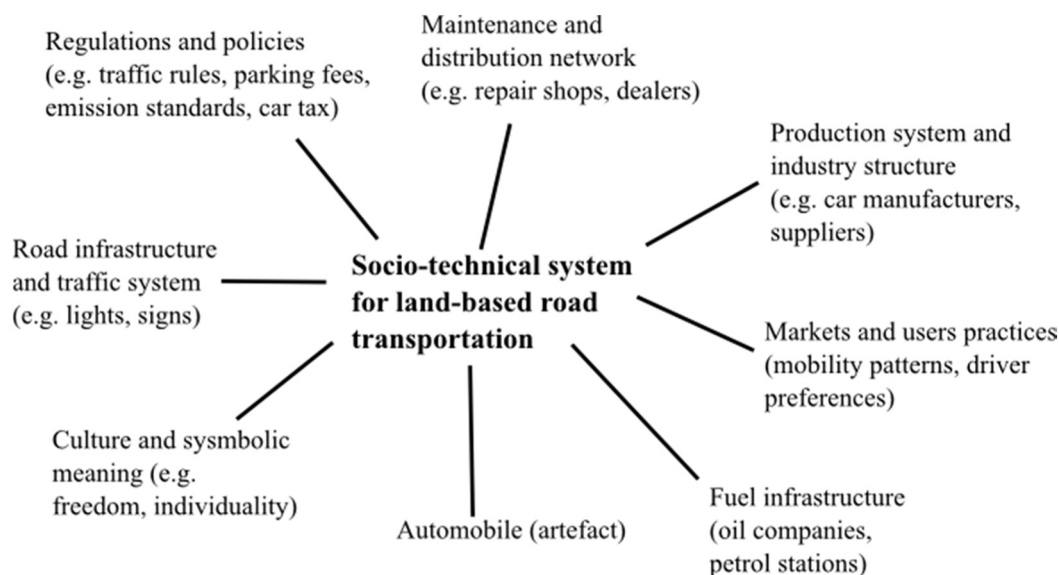

Fig. 1. A socio-technical system of transport.