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Technology adoption of electric bicycles: A survey among early adopters

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ABSTRACT

Electric bicycles (e-bikes) may reduce energy use, air pollution and noise for private transportation through a modal shift from fossil-fuel powered vehicles to e-bikes on short distance trips. However, designing effective promotion campaigns for the adoption of e-bikes requires detailed knowledge on user characteristics and motivations. In order to explain e-bike use on work, shopping and leisure trips, the present study combines concepts from technology adoption with factors derived from research on mobility behaviour. The study employs structural equation modeling to survey data from 1398 Austrian early adopters who purchased an e-bike between 2009 and 2011.

Results show that early adopters are predominantly comprised of persons aged 60 years or older who mainly use the e-bike for leisure trips. Carbon-intensive travel modes on commuting trips are barely substituted. Early adopters typically hold pro-environmental and technophile attitudes. E-bike use is most driven by perceived usefulness, which in turn depends on an easy use, appropriate infrastructure, also user's norms and attitudes towards environment and physical activity. Comparison by trip purpose shows that a supportive social environment and personal ecological norms influence e-bike use on work and shopping trips, whereas leisure use of e-bikes is driven by attitudes towards physical activity. Comparison by age groups underlines that older e-bike users are more dependent on practical usefulness of the technology and facilitating road infrastructure. Therefore, e-bike promotion strategies should differentiate between trip purpose and age segments when selecting target groups.

1. Introduction

Transport is one of the economic sectors within the European Union with the most detrimental effects on climate change. In 2007, private households in the EU-27 states produced 26% of their greenhouse gas emissions with transport activities (EEA, 2012). Furthermore, experts expect a 30% increase of passenger transport demand in the EU between 2010 and 2030 (EEA, 2012).

Electric bicycles (e-bikes) are considered as a potentially effective technological innovation to reduce carbon impacts, air pollution and noise from private transport: Surveys in Switzerland, Austria and UK indicate that electric two-wheelers can reduce energy use for transportation through a modal shift away from conventional cars powered by internal combustion engines (Cherry et al., 2009; BUWAL, 2004b; Kairos, 2010; Pierce et al., 2013). Given that most short-range trips in urban

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agglomerations are undertaken with the private car (BMVIT, 2011), a high potential for such a modal shift is seen in densely populated areas (BUWAL, 2004b). But also in rural areas, e-scooters and e-bikes might diversify travel model choice, for instance by substituting middle-range leisure trips otherwise undertaken with the car (Kairos, 2010).

Still, research agrees that the user is a critical parameter regarding net environmental benefits of e-bikes (BUWAL, 2004b; Kairos, 2010; Pierce et al., 2013). These benefits depend on the context and intensity of usage (e.g., regular work trips or occasional leisure trips) as well as the direction of modal shift (predominantly away from conventional cars and scooters or conventional bikes and public transportation). That is why the present study focuses on the motivation and behavioural patterns of e-bike users in Austria, extending previous research which almost exclusively investigated e-cars (such as Axsen and Kurani, 2012; Burgess et al., 2013; Borba et al., 2012; Oliver and Rosen, 2010).

In the context of the Austrian transport sector, it stands to reason to focus on e-bikes, because current market diffusion of electric vehicles in Austria consists to a major part of e-bikes: In 2010, almost 20,000 e-bikes, whereas only about 2560 e-scooters and 112 e-cars, were sold in Austria; in 2012, sales volumes rose to 45,000 e-bikes in contrast to 427 e-cars (Statistics Austria, 2011, 2013; VCÖ, 2011, 2013). While the market penetration of e-cars in general is impeded by their status as a 'work in progress' technology with uncertain technical reliability and life expectancy (Ahrend, 2011; Graham-Rowe et al., 2012; Oliver and Rosen, 2010), market entry of e-bikes was more successful. Hence, we can already find a considerable number of experienced e-bike users to investigate. In the long run, we can also hope that e-bikes represent an attractive transitional technology. Incurring lower costs and thus lower investment risks compared to e-cars or e-scooters, e-bikes may familiarize users with the pros and cons of electric propulsion systems, and thus could facilitate the subsequent market entrance of e-scooters and e-cars.

The market diffusion of e-bikes in Austria however, did not happen all by itself, but was strongly advocated by public policy. In recent years, several public administrations in Austria provided information, market access and subsidies for private households purchasing e-cars, -scooters or -bikes to accelerate the market uptake. In the years 2009–2011, more than 20,000 Austrian households received such funding, in most cases for e-bikes. These households can be considered 'innovators' or 'early adopters' according to Rogers (2003), as this small group spearheads the adoption of electric propulsion systems in a country of 4.6 Mio. conventional passenger cars (Statistics Austria, 2013): Therefore we surveyed 1398 Austrian households that recently received a subsidy for the purchase of an e-bike in order to gain insights into real-life reactions to this technology.

Previous studies doubt whether financial subsidies are successful in promoting a switch to alternative vehicle propulsion technologies (Saldarriaga-Isaza and Vergara, 2009). Ideally, subsidies should reach all population segments, and the e-bike should at least partially substitute previous car trips while not cannibalizing on other environmentally friendly transport modes. That's why we are interested in *characterizing early adopters* (e.g., socio-demographics, environmental values, technophilia) and their *e-bike use* (e.g., use of e-bikes, substitution of transport modes).

All surveyed households possess several months of personal everyday experience with their e-bike and have integrated the technology with their daily needs and activity schedules. Thus, we *explain the degree of e-bike use (adoption)* by assessing motivational factors related to e-bikes as an innovative technology, as well as a mode of transport. To that end, we combine theories of technology adoption (Venkatesh et al., 2003) with concepts to explain mobility behaviour (e.g. Bamberg et al., 2007; Hunecke et al., 2001). Previous studies point to differences in explanatory factors of cycling for transportation and recreation (Troped et al., 2003; Xing et al., 2010), therefore we compare the motives for e-bike adoption on working, shopping and leisure trips. Additionally, we investigate if users aged 60 years or more feature different motives than younger users, because the existing literature reports a moderator effect of age on technology adoption (Brown et al., 2010). For both research aims – the examination of variations by trip purpose and age – we employ multi group comparisons within a structural equation modelling framework.

Taken together, the present study provides empirical data about the characteristics of early adopters of e-bikes, how they reshape their mobility patterns due to the adopted technology and what motivations or product attributes drive their behavioural change. From a theoretical perspective, we conceptualize e-bike use as transport behaviour as well as technology adoption. Results shall support practitioners in identifying facilitating factors to increase the adoption of e-bikes – with or without offering public subsidies – as well as conditions under which e-bikes can promote sustainable transportation.

2. Theoretical background

2.1. Comparing e-bikes to other transport modes

E-bikes encompass powered bicycles as well as power assisted bicycles, often referred to as Pedelecs. They can be distinguished from e-scooters, other 'light electric vehicles' with 3 or 4 wheels (e.g., trikes, twikes) and e-cars, because e-bikes are not exclusively electrically powered and are not capable of higher velocities (BUWAL, 2004a; Rose, 2012).

Compared to cars, e-bikes allow more flexible and cheaper transport in urban areas and on short-range trips, unimpeded by parking restrictions. Compared to conventional bikes, they provide extended range without physical exhaustion, even more so in regions with hilly topography (Ahrens et al., 2013). However, the bike's disadvantages of exposure to weather, lacking transport capacity for passengers or luggage, and risk of bicycle theft apply, too. Still, the e-bike's intermediary role