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To what extent do e-bikes substitute travel by other modes? Evidence from the Netherlands

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ABSTRACT

After Asian countries, the e-bike is now also on the rise in many Western countries. Related to this development, an important question posed by scholars is to what extent the adoption of the e-bike will lead to environmental and health benefits. These will be present if the e-bike replaces travel by motorized modes. Surveying the literature addressing this issue, empirical studies conducted to date do indeed reach the conclusion that the e-bike is substituting travel by car. However, a general shortcoming of empirical studies is that substitution is assessed by asking direct questions to e-bike owners. The aim of the present study is to address this limitation and statistically assess the effect of e-bike ownership on various indicators of travel behavior. To this end, a conceptual model is developed, which is specified as a structural equation model and estimated using data from the last three national mobility surveys in the Netherlands (2013, 2014 and 2015). The results show that e-bike ownership strongly reduces the use of the conventional bicycle, but also, to a lesser extent, car and public transport use. Secondly, e-bike owners reduce their car and public transport use more than conventional bicycle owners. And thirdly, on the level of vehicle ownership, the e-bike acts as a substitute for the conventional bicycle and does not act as a substitute for the car. Overall, the results shed some light on the health and environmental benefits of the uptake of e-bikes in the Netherlands.

1. Introduction

After China and Japan, the world leaders in e-bike sales, the e-bike is now also becoming increasingly popular in European countries like The Netherlands, Denmark, Germany and Switzerland (Fishman and Cherry, 2016). For example, in the Netherlands, annual e-bike sales increased by 228% in the last 8 years, from 84,000 in 2007 to 276,000 in 2015 (Fietsplatform, 2016). In 2015, 28% of all bikes sold were e-bikes (Fietsplatform, 2016).

Alongside the fast uptake of this relatively new mode of transport, a related body of research has been developing. Within this body of literature an important question posed by scholars is to what extent the adoption of the e-bike will lead to environmental and health benefits (Fishman and Cherry, 2016). This mainly depends on the question for which mode the electric bicycle acts as a substitute; especially if motorized modes (e.g. car trips) are replaced will these benefits indeed occur (Weiss et al., 2015). A priori, it can be expected that, since the use of the e-bike is associated with greater speeds and trip distances than a normal bike (Fyhri and Fearnley, 2015), the e-bike has more potential than a normal bike to replace motorized modes. In addition, it should be noted that, next to replacing travel by other modes, the e-bike may also induce (generate) additional travel. Added health benefits could be generated for induced travel, even if replacing walk or other non-motorized modes.

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Surveying the literature addressing this issue (discussed in the next section), empirical studies conducted in various countries do indeed reach the conclusion that the e-bike is to some extent substituting travel by car. However, a general drawback of these studies is that e-bike owners are typically directly asked for which mode the e-bike acts as a substitute or what they consider as the best alternative for the e-bike. The answers to such questions may not be entirely valid and, at the least, are not very precise. In addition, they do not allow an assessment of possible generation effects.

The aim of the present study is to address these shortcomings and *statistically* assess the effect of e-bike ownership on travel behavior. For this purpose, a conceptual model is developed that includes various indicators of travel behavior (e-bike, bicycle, car and public transport use), variables related to vehicle ownership (e-bike, bicycle and car) and a set of control variables. To test the conceptual model, a structural equation model is specified, which is estimated using data from the last three national mobility surveys in the Netherlands (2013, 2014 and 2015) (Statistics Netherlands, 2013–2015). Since these data are representative of all residents in the Netherlands, they include both e-bike and non-e-bike owners, and thereby allow a statistical assessment of the influences of e-bike ownership on people's travel behavior.

2. Background literature

Since China was one of the first countries where the e-bike was adopted on a large scale, early studies addressing the substitution question were mainly conducted in this country. Based on an intercept survey in Shijiazhuang, Weinert et al. (2007) found that the bicycle was considered as the next best alternative for more than 60% of e-bike users. Using a similar methodology, Montgomery (2010), on the other hand, found that 65% of the e-bike users in Janin considered the bus as their next best alternative. In addition, the bus was also mentioned most often (48%) as the previously used mode. These results are consistent with those of two intercept surveys conducted by Cherry and Cervero (2007) in Kunming and Shanghai. In these cities, it was also found that most e-bike users indicated the bus was the preferred alternative (55%) and the previously used mode (51%). Following-up on this study, Cherry et al. (2016) came to similar findings, but also revealed that, over a 6-year period, the car was becoming increasingly 'popular' as the previously used mode (from 10 to 24%).

Along with the rise of the e-bike in Western countries, empirical studies from these countries have also become available. It should be noted that these studies are generally focused on pedal-assisted e-bikes, instead of electric (scooter-style) bikes without pedals, which are most popular (and thereby the subject of study) in Asian countries (Weiss et al., 2015; Fishman and Cherry, 2016).

Based on an internet survey among both types of bike owners in Australia, Johnson and Rose (Johnson and Rose, 2013) found that for the majority of the participants (60%) the motivation for purchase was to replace some car trips. A similar finding was reported by MacArthur et al. (2014) who conducted an online survey among (pedal-assisted) e-bike users in North America. In this study, 65% of the sample reported that a reason for purchase was to replace some car trips. A qualitative study among a small sample of e-bike owners in Sacramento (USA) revealed that most respondents (80%) indicated that they drove less since the purchase of the e-bike (Popovich et al., 2014). Finally, another small-sample study conducted among e-bike owners in Portland (Dill and Rose, 2012) revealed that the second most popular motivation for purchase was to provide an alternative to the car. In addition, some respondents indicated that they changed from driving a car to bicycling to work.

In contrast to these findings from car-dominated countries, an online survey among Dutch e-bike owners indicated that respondents were also replacing the bicycle (41%) in addition to the car (40%) (Lee et al., 2015). This finding is consistent with a recent study of Jones et al. (2016), who, among a small sample of English and Dutch e-bike owners, found that respondents reported decreases in (normal) cycling next to car use. In a similar fashion, Wolf and Seebauer (2014) found that Austrian e-bike owners were predominantly comprised of older persons who mainly used the e-bike for leisure trips. The authors concluded that carbon-intensive travel modes on commuting trips were barely substituted. Finally, again along the same lines, a study conducted among a sample of Danish e-bike users (Haustein and Møller, 2016) showed that the e-bike was considered as a replacement of the conventional bicycle as well as the car; 64% of the participants agreed that they used an e-bike on trips for which they would otherwise have used a conventional bike and 49% agreed that they used it on trips for which they would otherwise have used a car.

Overall, the findings from available studies indicate that the question which mode is substituted by the e-bike strongly depends on the local context and, in particular, the available transport alternatives. This point is also emphasized by Fishman and Cherry (2016) who note that in (Chinese) cities with high-quality transit systems (Shanghai or Jinan), e-bikes mainly substitute bus trips, whereas in cities underserved by public transport (Shijiazhuang) mainly bicycle trips are replaced. In a similar fashion, it can be observed that in car-dominated countries (Australia, US and Canada) mainly car trips are replaced, whereas in European countries with a bicycle orientation, the e-bike seems to substitute the conventional bike in addition to the car.

While the present study is not aimed at assessing the influences of the local context on the nature and degree of substitution of other modes, the (apparent) role of the local context is relevant insofar as it provides an expectation on beforehand regarding which modes will likely be substituted in the considered local context, i.e. The Netherlands. In this country, both car and the conventional bicycle can be considered as the dominant alternatives, and therefore most likely to be substituted.

From a substantive point of view, the study's contribution is thus that it provides (additional) evidence on the degree and nature of substitution from the Netherlands. However, the main contribution of the present study is methodological, namely