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Cycling on the extensive and intensive margin: The role of paths and prices

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ABSTRACT

Drawing on a panel of German survey data spanning 1999–2013, this paper identifies the correlates of non-recreational bicycling, focusing specifically on the roles of bicycle paths and fuel prices. Our approach conceptualizes ridership as a two-stage decision process comprising the discrete choice of whether to use the bike (i.e. the intensive margin) and the continuous choice of how far to ride (i.e. the extensive margin). To the extent that these two choices are related and, moreover, potentially influenced by factors unobservable to the researcher, we explore alternative estimators using two-stage censored regression techniques to assess whether the results are subject to biases from sample selectivity. A key finding is that while higher fuel costs are associated with an increased probability of undertaking non-recreational bike trips, this effect is of a significantly higher magnitude among those residing in an urbanized region. We also find evidence for a positive association with the extent of bike paths, both in increasing the probability of non-recreational bike travel, as well as the distance traveled.

1. Introduction

The promotion of bicycling is widely recognized to advance multiple goals toward sustainable transportation policy. Beyond reducing air pollution, noise, congestion, and other negative externalities associated with the automobile, bicycling may improve an individual's health status, increases mobility, and affords shelter from volatile fuel prices. In recognition of these benefits, the German government recently released a traffic plan that aims to increase the share of bicycle trips from 10% to 15% by 2020 (BMVI, 2016), a particularly ambitious objective given the 47% increase in total bicycle mileage already achieved between 2000 and 2012.

Reaching the new target raises the question of what policy-levers can be availed to encourage bicycle usage. A sizable literature has emerged to address this topic, comprehensively summarized in reviews of bicycle studies by Heinen et al. (2010) and Handy et al. (2014). A recurrent theme is that public policy can play an effective role in promoting bicycling, especially insofar as it shifts the relative costs of alternative transport modes in favor of cycling.

Two broad and partially overlapping strands of the literature have emerged in this vein, one of which emphasizes the role of non-monetary factors, such as those related to safety, physical effort, time, the enjoyment derived from the trip, and other determinants that attract or repel people from using the bicycle (Rietveld and Daniel, 2004; Handy et al., 2010; Ritter and

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Vance, 2011). The associated policy interventions evaluated in this literature include traffic speed and volume, bicycle infrastructure, and integration with public transit (Rodrıguez and Joo, 2004; Moudon et al., 2005; Parkin et al., 2008; Winters et al., 2011; Braun et al., 2016), as well as communication campaigns that propagate information on the benefits of cycling (Lanzendorf and Busch-Geertsema, 2014) and harness social network effects (Goetzke and Rave, 2011).

Another strand of the literature has emphasized the importance of monetary costs, a central premise being that increases in the marginal costs of alternative modes, particularly for the automobile (Frondel and Vance, 2013), is among the most effective ways to increase bicycling (Pucher et al., 1999; Bergström and Magnusson, 2003; Pucher and Buehler, 2008). Studies by Noland and Kunreuther (1995) and Sardianou and Nioza (2015), for example, both establish a correlation between perceived automobile cost and preferences for bicycling. Other work focuses on the role of observed costs. Pucher and Buehler (2006) and Buehler and Pucher (2012) identify a large positive association between the gasoline price and the percentage of work trips by bike using samples of data drawn from Canada and the U. S. Focusing on the U. S., Rashad (2009) also finds a positive association between higher gasoline and bicycle use. As in the literature addressing non-monetary factors, empirical studies of monetary costs have generally focused on the discrete choice of whether to use the bike, with a relatively smaller number exploring the extent of bicycling (e.g. Rietveld and Daniel, 2004; Buehler and Pucher, 2012).

Using household level survey data from Germany, the present paper draws on elements from both these strands to identify policy tools – both monetary and non-monetary – for increasing cycling. Our approach distinguishes itself from existing work by conceptualizing cycling as a two-stage decision process comprising whether to ride (i.e. the intensive margin) and the continuous choice of how far to ride (i.e. the extensive margin). To the extent that these two choices are related and, moreover, potentially influenced by factors unobservable to the researcher, we explore alternative estimators using two-stage censored regression techniques to assess whether the results are subject to biases from sample selectivity. We are particularly interested in quantifying the roles of transport infrastructure and fuel costs as determinants of bicycle use.

A key finding is that while higher fuel costs are associated with an increased probability of undertaking non-recreational trips with the bike, this effect is of significantly higher magnitude among those residing in an urbanized region. We also find evidence for a positive association with the extent of bike paths, both in increasing the probability of non-recreational bike travel, as well as the distance traveled.

The next section describes the data sources and their assembly for the quantitative analysis. Section 3 describes the econometric models, the explanatory variables included in the specification, and some technical details on the interpretation of the marginal effects. Section 4 catalogs the results, and Section 5 concludes the paper.

2. Data assembly

The primary data source used in this research covers the 1999–2013 waves of the German Mobility Panel (MOP), a representative multi-year travel survey financed by the German Federal Ministry of Transport and Digital Infrastructure. Participating households are surveyed daily for a period of one week over each of three years, after which they exit the panel. The information collected includes individual attributes such as age, gender, and employment status, as well as mobility-related characteristics such as possession of a driver's license and ownership of a bicycle (Table 1).

It also includes household attributes, such as income, car ownership, proximity to the nearest transit stop, residence in an urbanized county (i.e. counties with over 100,000 people or 300 people per square kilometer, as designated by Germany's

Table 1
Variable definitions and descriptive statistics.

Variable name	Variable definition	Mean	Std. dev.
Lack of cars	Dummy: 1 if the number of driver licenses is larger than the number of cars in the household	0.448	–
Lack of bikes	Dummy: 1 if the number household members is larger than the number of bikes in the household	0.162	–
Transit proximity	Walking distance in minutes to public transit stop	5.664	4.726
Rail transit	Dummy: 1 if this stop is serviced by rail transit	0.102	–
Bike path extent	Total length of bike paths in 100 km	1.120	1.312
Urban	Dummy: 1 if household is situated in urbanized county	0.381	–
Petrol price	Petrol price in Euros per liter	1.140	0.280
Open space	Area of undeveloped land in 1000 square km	0.753	0.603
County size	Areal extent of residence county in 1000 square km	0.864	0.605
# Rainy days	Number of rainy days in a week	2.390	1.481
Temperature	Average weekly temperature in degree Celsius	10.366	3.709
Female	Dummy: 1 if respondent is female	0.515	–
Degree	Dummy: 1 if respondent has a post-high-school degree	0.413	–
Age	Age of respondent in years	48.725	15.144
# Kids	Number of kids in the household	0.492	0.819
License	Dummy: 1 if respondent owns a driving license	0.946	–
High income	Dummy: 1 if real monthly household income $\geqslant$ 3000 €	0.356	–
Middle income	Dummy: 1 if real monthly household income $\geqslant$ 1500 € and <3000 €	0.540	–
Full time employed	Dummy: 1 if respondent is full time employed	0.408	–
Year trend	Year of observation	2005.9	4.435