Socio-economic and spatial determinants of car ownership in Germany

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Research Motivation

- Car ownership is associated with externalities, including air and noise pollution, congestion and accidents.
- There are many stakeholders who need information on future car ownership, e.g. traffic planers.
- For many years, the German government has pursued policies that combine high fuel taxes and land use planning measures to reduce automobile dependency.
- The efficacy of particular policy measures associated with such development has rarely been subjected to scrutinity.

Research Question

- How do spatial configuration and socio-economic attributes of a household influence its level of car ownership?

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Literature on car ownership

- The recent literature on car ownership draws on disaggregate data to focus on the role of household characteristics.
- Car ownership models often include household income and demographic structure, employment status, availability of car sharing and public transport.
- Like most of the work that links urban form and mobility, the majority of investigations draw on North American data.
- Drawing on household level data, the present study contributes to this line of inquiry with a multinomial logit analysis of car ownership in Germany.

Data

- The household data used in this research is drawn from the German Mobility Panel.
- It covers thirteen years, spanning 1996 through 2008.
- The panel is organized in overlapping waves, each comprising a group of households surveyed for a period of up to three consecutive years.
- The questionnaire elicits general household information, person-related characteristics and relevant information on everyday travel behavior.
- The sample includes 5,675 households, 1,856 of which appear one year in the data, 1,281 of which appear two years and 2,538 of which appear three consecutive years. Altogether, we are faced with 12,032 observations.

Table 1: Descriptive Statistics

Variable	Description	Mean	Std. Dev.
# cars	number of cars in household	1.118	0.719
# of retired	number of retired in household	0.493	0.705
# of full time workers	number of full time workers in household	0.678	0.704
# of part time workers	number of part time workers in household	0.259	0.458
# of children	number of children in household	0.437	0.827
# of licenses	household members with driving licenses	1.560	0.843
monthly net income	monthly net income in 1000 Euros of 2000	2.095	0.788
population density	population density in 1000 people per km^2	0.959	1.098
minutes	walking distance in minutes to nearest public transport	5.690	4.818
tram / subway / train station	1 if nearest public transport station is a tram, subway or train station	0.224	0.417
company car: business trips only	1 if household has company car restricted to business trips	0.009	0.096
company car: private use allowed	1 if household has company car not restricted to business trips	0.047	0.212
fuel price	fuel price in Euro per liter of 2000	1.024	0.112
fare price	monthly fare price in Euro of 2000	32.585	5.647

The Econometric Model

- As a categorial variable, car ownership is usually analyzed using discrete choice models
- Bhat and Pulugurta (1998) argue in favor of multinomial models, as these are consistent with global utility maximization on behalf of the household compared to ordered-response models.
- The basic idea of employing multinomial models is that a household associates a certain level of utility with each car owned.
- Multinomial models come with the advantage that parameters can vary unrestricted over the car ownership levels.
- However, these models come at the expense of having to estimate more parameters.

Multinomial Logit

- The structural model describes the probability of car ownership:

$$U_{ij} = x_i^T \cdot \beta_{ij} + \epsilon_{ij} \tag{1}$$

- x is a vector of exogenous variables related to household i.
- Subscript j denotes the number of cars.
- β is a vector holding the parameters for each level of car ownership.
- U measures the utility associated with household i's level of car ownership j.
- Although utility is unobservable, we can observe the outcome with the highest utility.

Multinomial Logit

- The probability that we observe a car ownership level j for household i, conditional on the regressors is:

$$P(y_i = j) = \frac{exp(x_i^T \cdot \beta_j)}{\sum_{l=0}^{m} exp(x_i^T \cdot \beta_l)} \; , n = 0, 2, 3; i = 1, \ldots, N. \qquad (2)$$

- Multinomial logit models require a base case as a reference for interpretation, which in our case is the single-car household.
- This approach makes sense, given that the majority of German households (approx. 53%) are single-car households and it is most interesting to know what makes households deviate from this level of car ownership.

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Multinomial Logit

- We obtain the marginal effect by differentiating with respect to the variable of interest k:

$$ME_{ijk} = \frac{\partial P(y_i = j)}{\partial x_{ik}} \tag{3}$$

Table 2: Multinomial Logit Regression Results

	no cars	2 cars	3+ cars
# of retired	0.141	**-0.437	**-0.464
	0.090	0.084	0.172
# of full time workers	**0.311	**0.221	**0.424
	0.119	0.082	0.151
# of part time workers	0.121	**0.340	*0.373
	0.136	0.085	0.169
# of children	-0.024	**-0.140	**-0.563
	0.088	0.045	0.110
# of licenses	**-2.354	**1.234	**2.455
	0.109	0.077	0.146
monthly income	**-2.974	**1.089	-1.018
	0.304	0.353	0.671
monthly income squared	**0.000	0.000	**0.000
	0.000	0.000	0.000
population density	**0.373	**-0.307	**-0.536
	0.046	0.045	0.155
minutes	**-0.058	**0.028	**0.055
	0.012	0.007	0.013
tram / subway / trainstation	**0.410	**-0.466	**-0.589
	0.105	0.102	0.227
company car: business trips only	0.702	**-1.751	**-18.087
	0.478	0.338	0.515
company car: private use allowed	**3.282	**-2.929	**-21.945
	0.220	0.218	0.800
fuel price	0.735	-0.584	-1.023
	1.273	1.070	2.993
fare price	-0.002	0.000	-0.029
	0.009	0.008	0.019
constant	**3.322	**-5.454	**-8.141
	1.183	1.035	2.892

Standard errors in brackets. ** denotes significance at 1% level, * at the 5% level.

Table 3: Marginal Effects from Multinomial Logit Regression

	no car	2 cars	3+ cars
# of retired	*0.009	**-0.056	*-0.001
	0.004	0.010	0.000
# of full time workers	*0.012	*0.026	*0.001
	0.005	0.010	0.000
# of part time workers	0.003	**0.042	0.001
	0.006	0.011	0.000
# of children	0.000	**-0.017	**-0.001
	0.004	0.006	0.000
# of licenses	**-0.108	**0.170	**0.004
	0.008	0.010	0.001
monthly income	**-0.133	**0.156	-0.002
	0.020	0.040	0.000
monthly income squared	0.000	0.000	0.000
	0.000	0.000	0.000
population density	**0.018	**-0.041	**-0.001
	0.000	0.010	0.000
minutes	**-0.003	**0.004	**0.000
	0.001	0.001	0.000
tram / subway / trainstation	**0.023	**-0.056	*-0.001
	0.006	0.010	0.000
company car: business trips only	0.053	**-0.121	**-0.002
	0.041	0.011	0.000
company car: private use allowed	**0.517	**-0.161	**-0.005
	0.043	0.007	0.001
fuel price	0.035	-0.078	-0.002
	0.055	0.134	0.005
fare price	0.000	0.000	0.000
	0.000	0.001	0.000

Standard errors in brackets. ** denotes significance at 1% level, * at the 5% level.

Conclusions

- We find evidence that the number of cars a household owns increases with the number of licensed drivers in the household and the income.
- Regardless of usage restrictions, the prevalence of company cars reduces ownership levels.
- Neither fuel nor fare prices have a significant influence.
- The nearer the next public transport stop, the lower the car ownership level.
- The service level, as proxied by the rail transit dummy, also lowers the car ownership level.