Travel Time Differences Between Cargo Cycles and Cars for Commercial Transport

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A large, curved image of the Earth from space occupies the bottom right portion of the slide. It shows a blue horizon, white clouds, and green landmasses, including parts of Europe and Africa.

Knowledge for Tomorrow

AGENDA

Background

- Introduction & research questions
- State of the art
- Project background
- Collection of trip data
- Fleet characteristics

Travel times of cargo cycles and cars

Model estimation & results

Model application & scenario analysis

Conclusion

Introduction & Research Questions

- Diesel bans in Germany
- Government is assessing promotion of cargo cycles
- General potential is seen, but mixed results for operative feasibility
- Reservations among fleet decision-makers, constraints:
 - Load carrying capacity → no focus today
 - Travel time performance compared to cars → focus of this talk
- Research Questions
 1. What are the differences in travel times between cargo cycles and cars when used for commercial transport operations?
 2. Which factors affect these travel time differences?

State of the Art & own research agenda

- Few findings in commercial transport
e.g. Conway 2017: one cargo cycle model used by two operators in Manhattan
- Cycles can be competitive
- Some findings from private cycling can be helpful

Factors to be explored:

Spatial context

- Trip distance
- Cycle shortcuts
- Road grade
- City size
- Car ownership per capita
- Quality of bicycle infrastructure

Time

- Peak and off-peak hours
(subsequently: network load)
- Weekday vs. weekend

Vehicle

- Basic construction type (2 or 3-wheeler)
- Electric assist

Trip conditions

- Weather
- Payload utilization
- Trip purpose

Project “Ich entlaste Städte” (*Taking the load off cities*)

- Germany-wide cargo cycle testing scheme
- Managed by German Aerospace Center (DLR)
- Funded by Federal Ministry for the Environment
- Diverse target group: companies of all industries, public organizations, freelancers, associations etc.
- Testing period: 3 months, cost: US \$30 monthly
- ➔ Sample size: 84 participants, 1.421 cargo cycle trips

One of the project bikes

Organizational & spatial background of 84 participants

- Freelance, self-employed
- Company
- Public authority
- NGO, association

Collection of Trip Data

Cargo cycles

vs.

Cars

- Tracked trip data records (n=1.421)
- Use of project app to record cargo cycle trips
- Collection time: October 2017 – May 2018

- Synthetic trip data
- Use of Google Maps car routing algorithm
- Input: origin, destination, starting time
- Output: Two estimates
 - 'best guess' (BG)
 - 'pessimistic'

→ **Dependent variable:** Δ travel time (cargo cycle) vs. travel time (car – BG), in minutes

Fleet Characteristics

No. of wheels	Construction type	Side view of typical model	No. of models	Models with electric assist	No. of vehicles
Two-wheeler	Pizza delivery bike		1	1x Pedelec-25	8
	Long John bike		9	1x without 7x Pedelec-25 1x Pedelec-45	56
	Longtail bike		2	1x without 1x Pedelec-25	4
Three-wheeler	Tricycle, front load		5	5x Pedelec-25	15
	Heavy-load tricycle		1	1x Pedelec-25	1

Pedelec-25:

- Assisted pedaling
- Max. 25 kph (15.5 mph)
- No license, no insurance
- Regulated as “conventional” bicycle

Pedelec-45 / “fast e-bike”

- Assist without pedaling possible
- Max. 45 kph (28.0 mph)
- License, insurance needed
- Regulated as moped

Travel Times of Cargo Cycles and Cars

Model Estimation

- Goal: Applicability for commercial transport operators → easy-to-obtain variables
1. OLS model ($R^2=0.755$) showed expected signs of variables
 2. GLS model to correct for heteroskedasticity
 3. Random intercept model to correct for clustering effect of participants
→ final model

OLS Model

GLS Model

Random Intercept Model

		OLS Model	GLS Model	Random Intercept Model
5-fold Cross-validation	MSE	20.441	20.669	20.114
	Adj. R^2	0.755		
Goodness of fit indicators	AIC	8196	7712	7617
	BIC	8259	7775	7680
	Log likelihood	-4086	-3844	-3797

Model Results: Coefficients

Variable group	Variable name	Random Intercept Model			
		Coeff.	Estimate	Std. err.	t. Statistic
Spatial context	<i>Intercept</i>	β_{CON}	2.318	0.596	3.889 (***)
	cycleTripDistance	β_{TD}	1.696	0.032	53.279 (***)
	elevationDifferenceManualCycle	$\beta_{\text{ED-M}}$	0.129	0.026	5.017 (***)
	elevationDifferenceElectricCycle	$\beta_{\text{ED-E}}$	0.020	0.004	4.513 (***)
	distanceShortcutCargoCycle	β_{DS}	-1.665	0.109	-15.308 (***)
	log(carOwnership)	β_{CO}	-0.512	0.106	-4.848 (***)
Time	isMorningTime	β_{6-10}	-1.318	0.357	-3.692 (***)
	isDayTime	β_{10-19}	-0.993	0.296	-3.352 (***)
Vehicle	isThreeWheeler	β_{3W}	2.066	0.504	4.100 (***)
	isElectric45	β_{E45}	-1.292	0.632	-2.044 (*)
Trip conditions	<i>Standard deviation of intercept</i>	σ_{CON}	1.126		
	<i>(insignificant)</i>				

- Dependent variable: Δ Travel time (cargo cycle) vs. travel time (car - BG), in minutes
- Note: **Negative betas** indicate travel time advantages for **cargo cycles**.

Model Results: Summary

- General superiority of mode “car” (2.3 min), but overlapped by other factors, leveling out opportunities
- Important factors:

Spatial context	Significant factors	Insignificant factors
Time	<ul style="list-style-type: none"> • Increasing trip distance = advantage for cars • Road grade: obstructive, but manageable by electric assist • Cycle shortcuts: effective tool for planning • Car ownership per capita: Denser cities favor cargo cycles 	<ul style="list-style-type: none"> • City size • ADFC index of bicycle infrastructure
Vehicle	<ul style="list-style-type: none"> • Peak vs. off-peak hours: Activities in the morning and throughout the day are favorable for cargo cycles 	<ul style="list-style-type: none"> • Weekend
Trip conditions	<ul style="list-style-type: none"> • Basic layout: 2-wheelers advantageous • Electric assist: advantages for “Pedelec-45” 	<ul style="list-style-type: none"> • (General) electric assist
	<ul style="list-style-type: none"> • None 	<ul style="list-style-type: none"> • Weather (temperature, precipitation) • Trip purpose • Loading capacity: full or overloaded

Model Application and Scenario Analysis: Preparation

Model application
for car courier trips

Sample data & model

Congested scenario
analysis

- leeA database with 9,821 direct deliveries by car (out-of-sample prediction)
- Conducted by 205 self-employed messengers in 8 German cities in March 2014
- Travel time prediction for 2-wheeled cargo cycles with 'Pedelec-25' electric assist
- Calculation of travel time differences

- Assumption 1: *Car drivers face congested traffic conditions.*
→ "Pessimistic" values for car routing applied
- Assumption 2: *Cargo cycle rider uses Google's bicycle routing for optimal routes.*
→ Correction factor 0.95 applied (empirically derived)
- New travel time differences were calculated

Model Application and Scenario Analysis: Results

CONCLUSION

Applicable results and sensitivities of modal shift for practitioners.

**For practitioners:
Direct deliveries of up to ~3 miles are potentially very attractive under the right conditions.
(Split-up opportunity for micro-consolidators)**

Increasing congestion further reduces travel time differences, making cargo cycles a competitive alternative.

**For policy-makers:
Small policy changes (e.g. parking regulation) have substantial effects on closing the travel time gap.**