

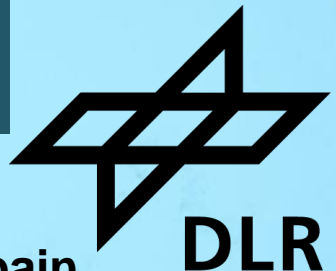
VEHICLE ELECTRIFICATION IN INFORMAL TRANSPORT

Marc Hasselwander ^(a), Jacqueline Senyagwa ^(b), Emilie Martin ^(b),
Vera-Marie Andrieu ^(b), Mirko Goletz ^(a), Oliver Lah ^(b)

(a) Institute of Transport Research, German Aerospace Center (DLR), Germany

(b) Urban Electric Mobility Initiative (UEMI), Germany

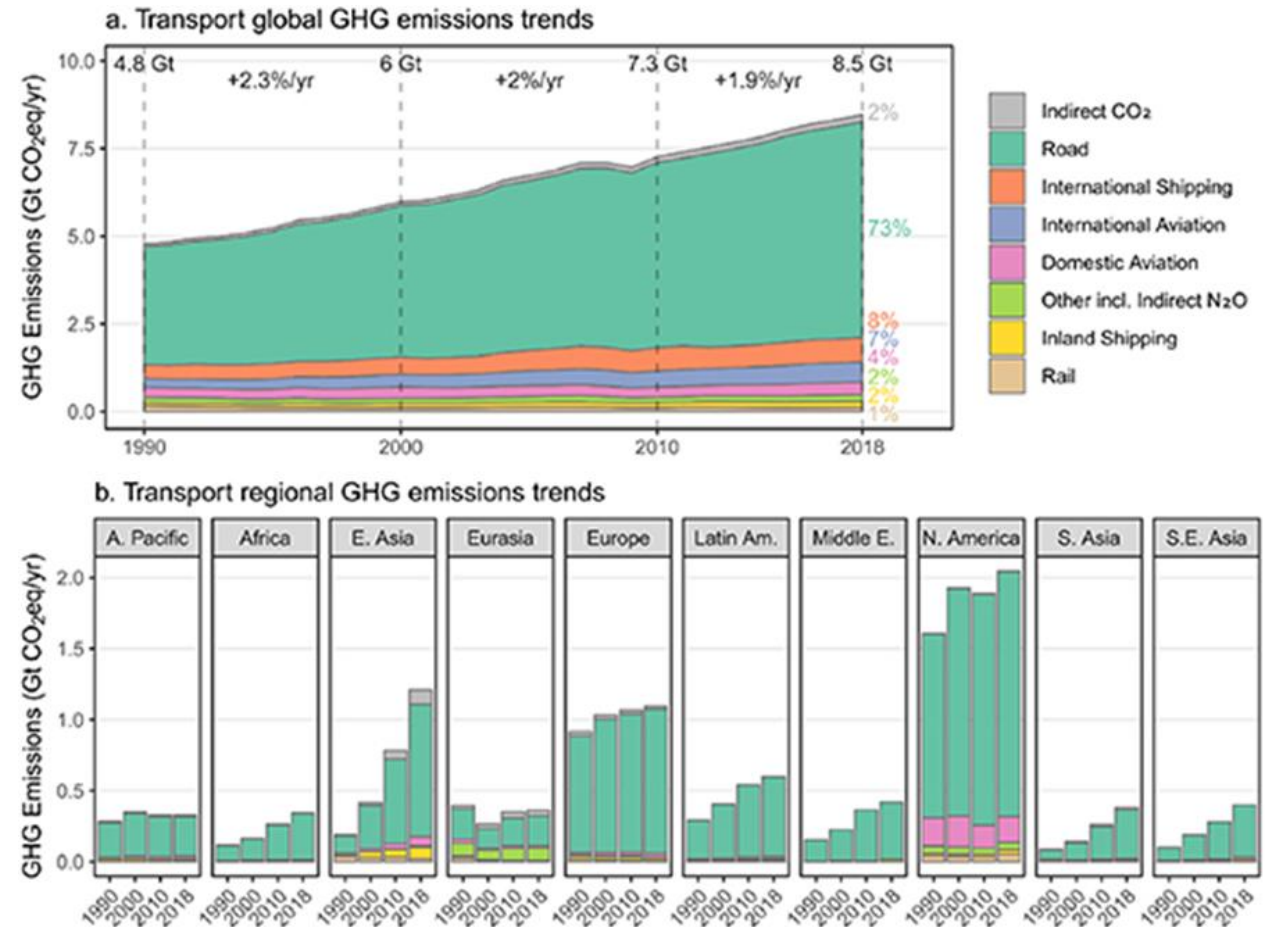
Urban Transitions Global Summit 2022, 8-10 November 2022, Sitges, Barcelona, Spain.



BACKGROUND

Environmental impact of transportation

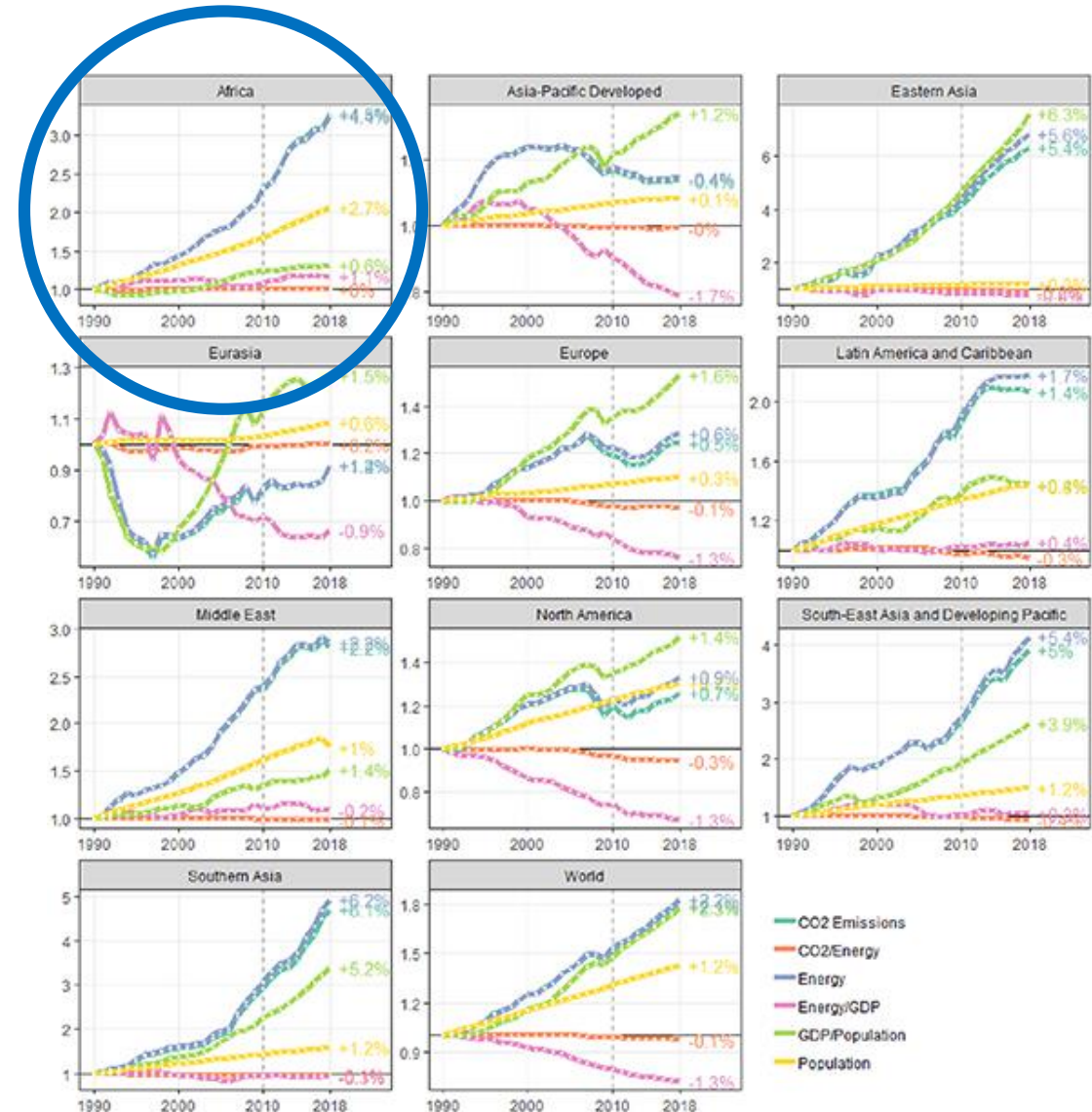
- negative externalities: deterioration of the environment, accidents, noise, air pollution
- transport sector = one of the largest emitters and fastest-growing source of GHG emissions
- especially, road-based transportation
- great disparities between low and high income regions



Source: Lamb et al. (2021). A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018. Environmental Research Letters, 16, 073005.

Environmental impact of transportation (cont'd)

- fastest growth observed in the global South, e.g., Africa (+3.3%/yr, +0.08 GtCO₂eq)
 - fast growing economies, population growth, and urbanization fuel transport demand
- **decarbonisation** of transport is of utmost importance



Source: Lamb et al. (2021). A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018. Environmental Research Letters, 16, 073005.

The role of informal transport

- most popular travel option in many developing cities
- made up of small-sized (often old) vehicles, owned by individuals, operated without official endorsement



Source: Fred Inklaar/Flickr

Estimated numbers of motorcycle-taxis in selected cities and countries.

City or country	Numbers and mode	Local name	Year of data	Case study
Aba (Nigeria)	13,500 three-wheelers	<i>keke napep</i>	2011	Nwaogbe et al. (2012)
Douala (Cameroon)	47,103 two-wheelers	<i>bendskin</i>	2015	Adiang et al. (2017)
Kampala (Uganda)	40,000 two-wheelers	<i>boda-boda</i>	2011	Goodfellow and Titeca (2012)
Kigali (Rwanda)	10,486 two-wheelers	<i>taxi-motos</i>	2012	Rollason (2012)
Lagos (Nigeria)	200,000 two-wheelers	<i>okada</i>	2007	Kumar (2011)
Lokoja (Nigeria)	11,875 two-wheelers	<i>okada</i>	2009	Aderamo and Olatujoye (2013)
Lomé (Togo)	90,000 two-wheelers	<i>oleyia</i>	2009	Guézéré (2015)
N'Djamena (Chad)	15,000–22,000 two-wheelers	<i>clando</i>	2013	Mahamat Hemchi (2015)
Kenya	140,215 two-wheelers	<i>boda-boda</i>	2011	Nasong'o (2015)
Tanzania	832,149 two-wheelers	<i>boda-boda</i>	2014	Bishop and Amos (2015)
	53,874 three-wheelers	<i>bajaj</i>		

Source: Ehebrecht, D., Heinrichs, D., & Lenz, B. (2018). Motorcycle-taxis in sub-Saharan Africa: Current knowledge, implications for the debate on “informal” transport and research needs. *Journal of transport geography*, 69, 242-256.

- Question: **How to foster a clean energy transition (i.e., electrification of vehicles) in informal transport?**

The background of the slide is an aerial photograph of a coastal city, likely Hong Kong, showing a dense urban landscape with numerous high-rise buildings and a large harbor with several ships. A dark blue horizontal band is overlaid across the middle of the image, containing the title text.

CASE STUDY PRESENTATION

Dar es Salaam

largest city of Tanzania

- Population: ca. **6,400,000**
- Between 2002-2012: **5.6%** average annual growth rate (!)

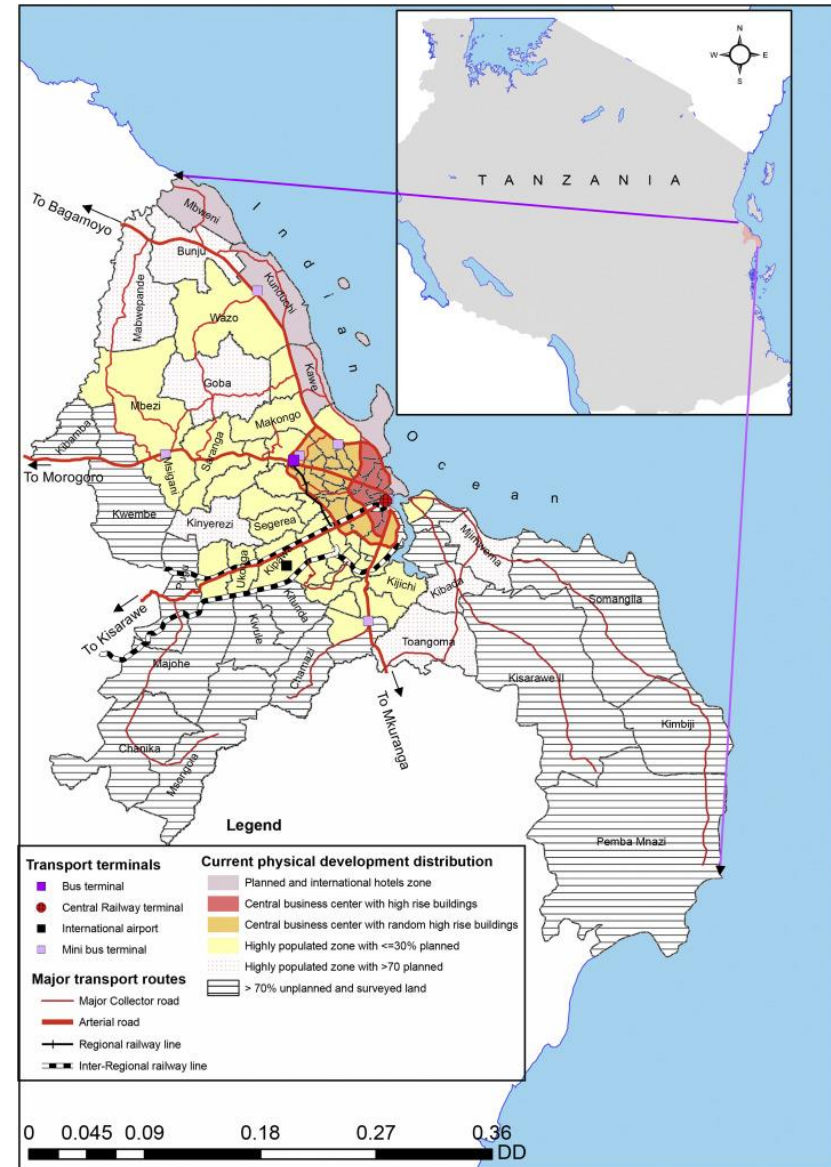
BRT system introduced in 2016

- 21.1 kilometers, 29 BRT stops**
- First phase (6 planned)



Informal transport

- Minibuses: **dala dala**
- Local three-wheelers: **bajaj**



Source: Bwire, H., & Zengo, E. (2020). Comparison of efficiency between public and private transport modes using excess commuting: An experience in Dar es Salaam. *Journal of Transport Geography*, 82, 102616.

A large satellite with two long, rectangular solar panel arrays is shown in orbit above the Earth. The satellite's body is gold-colored with various instruments and antennas. The solar panels are white with a grid of solar cells. The Earth below shows a mix of green land, blue oceans, and white clouds. The curvature of the planet is visible on the right side of the image.

MATERIAL AND DATA

EU-funded [Solutions+](#) project:

- **face-to-face survey with bajaj drivers (N=152) at five waiting points near BRT stations**
 - drivers' socio-economic profile, characteristics of current bajaj operations, and stated interest and preferences for electric vehicles
- GPS tracking campaign
- boarding and alighting survey
- frequency occupancy survey
- passenger survey



Source: Senyagwa, 2022

Model estimation and analysis

- Utility theory
- Binary probit model of drivers' **stated interest in electric vehicles:**

$$y_j^* = \beta x_j + \varepsilon_j,$$

- Estimation of marginal effects:

$$\frac{\partial E[y_i|x_i]}{\partial x_i} = \phi(y'x_i)$$

- Variable selection: purposeful selection process (Bursac et al., 2008)

Variable	Description	Category	Observations (% of sample)	Mean (SD)
AGE	Age of bajaj driver	-	-	30.66 (5.98)
EDU	Highest level of completed education of bajaj driver	Primary	46 (30.3)	-
		Secondary	74 (48.7)	-
		Vocational	25 (16.4)	-
		University	6 (3.9)	-
BRAND	Brand of the bajaj (=1 if the bajaj is a BTV King)	-	124 (81.6)	-
OWNER	Bajaj ownership model			
-1	(=1 if the driver is the owner of the bajaj and bought it cash)	-	15 (9.9)	-
-2	(=1 if the driver is the owner of the bajaj on a hire-purchase agreement)	-	34 (22.4)	-
-3	(=1 if the driver is renting the bajaj on a hire-to-owner agreement)	-	69 (45.4)	-
-4	(=1 if the driver is purely renting the bajaj)	-	28 (18.4)	-
RENTAL	Bajaj rental model			
-1	(=1 if the bajaj is rented on a daily basis)	-	100 (65.8)	-
-2	(=1 if the bajaj is rented on a weekly basis)	-	14 (9.2)	-
-3	(=1 if the bajaj is rented on a monthly basis)	-	3 (2.0)	-
LOGPRICE	Purchase price of the bajaj in Tanzanian shilling (log scale)	-	-	15.78 (2.48)
EBM	Preferred ownership model for electric bajaj			
-1	(=1 if the driver prefers upfront purchase)	-	9 (5.9)	-
-2	(=1 if the driver prefers hire-to-own purchase)	-	110 (72.4)	-
-3	(=1 if the driver prefers pure rental)	-	33 (21.7)	-
LOGFUELD	Drivers' average daily fuel expenses in Tanzanian shilling (log scale)	-	-	9.84 (0.20)
LOGREPAIRSM	Drivers' average monthly expenses for repairs and maintenance in Tanzanian shilling (log scale)	-	-	10.93 (0.29)
TRIPSD	Number of passenger trips per day	0-4	0	-
		5-9	4 (2.6)	-
		10-14	24 (15.8)	-
		15-19	18 (11.8)	-
		20+	106 (69.7)	-
KM	Average distance traveled with bajaj per day in km	-	-	91.31 (86.51)
BAJAJAGE	Age (in years) of the drivers' current bajaj	-	-	4.24 (2.08)
PARK1	Overnight parking location of the bajajs			
-1	(=1 if the driver parks the bajaj in a guarded parking space)	-	95 (62.5)	-
-2	(=1 if the driver parks the bajaj at the waiting point)	-	4 (2.6)	-
-3	(=1 if the driver parks the bajaj outside their home)	-	45 (29.6)	-
MEMBER	Drivers union/association membership (=1 if the driver is a member)	-	125 (82.2)	-
APP	Usage of ride-hailing apps (e.g., Uber, Bolt) (=1 if the driver uses an app)	-	9 (5.9)	-
EBAJAJ	Stated interest in electric bajajs (=1 if the driver is interested)	-	125 (82.2)	-



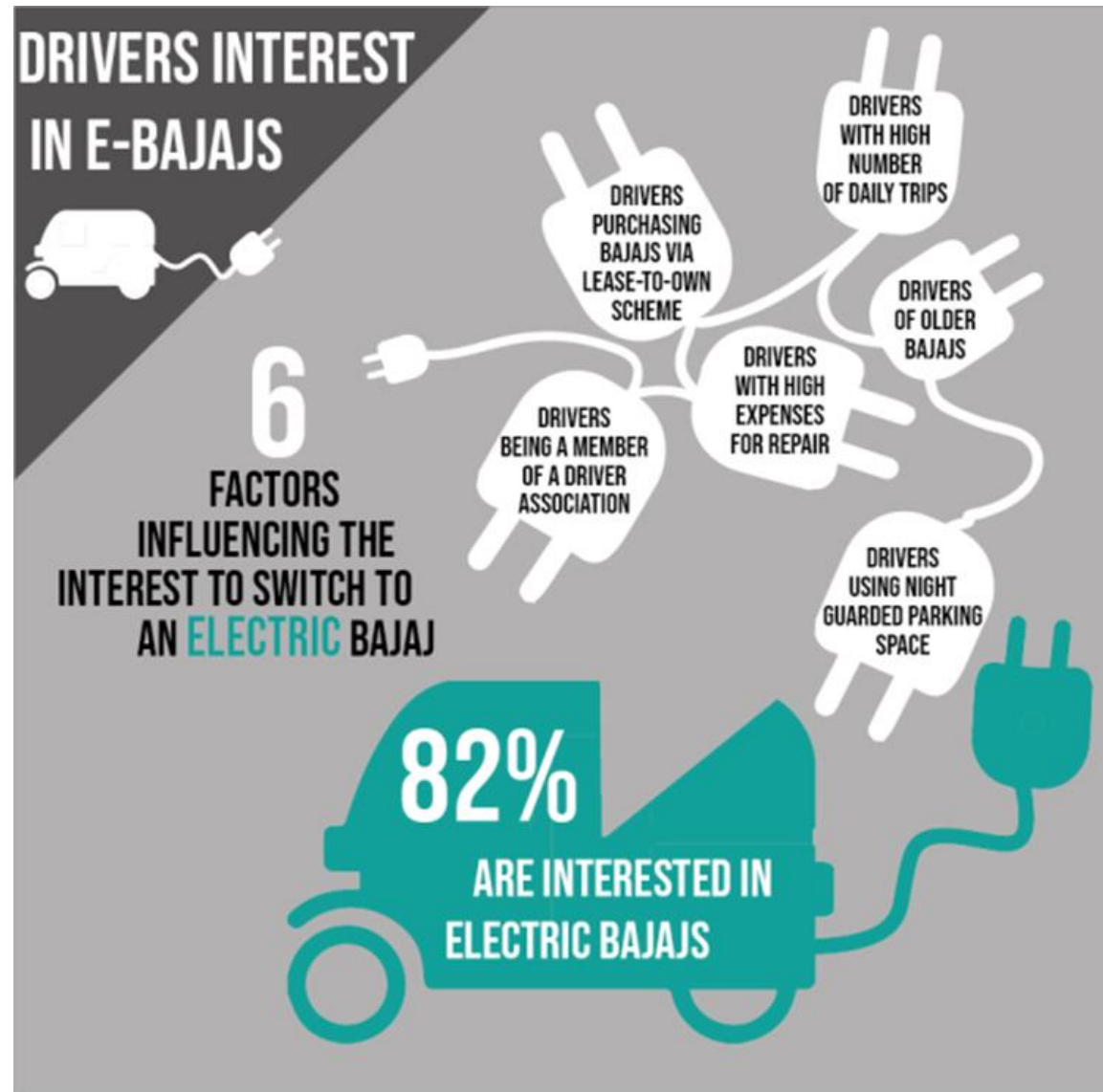
RESULTS AND DISCUSSION

Model results



Variable	Coefficient	Std. error	Ave. ME
(Constant)	-19.7048	13.7940	
OWNER3	0.5285	0.5664	0.05978
EBM2	0.8420	0.6454	0.09525
LOGFUELD	0.9621	1.3570	0.1088
LOGREPAIRSM	0.5969	0.9647	0.06752
TRIPSD	0.5823	0.3294	0.06587
BAJAJAGE	0.3705	0.1534	0.04192
PARK1	1.0472	0.5922	0.1185
MEMBER	0.2505	0.7582	0.02834
Model summary statistics			
Number of observations:	152		
Number of model parameters:	8		
Log likelihood:	-53.78795		
McFadden Pseudo R-squared:	0.243521		

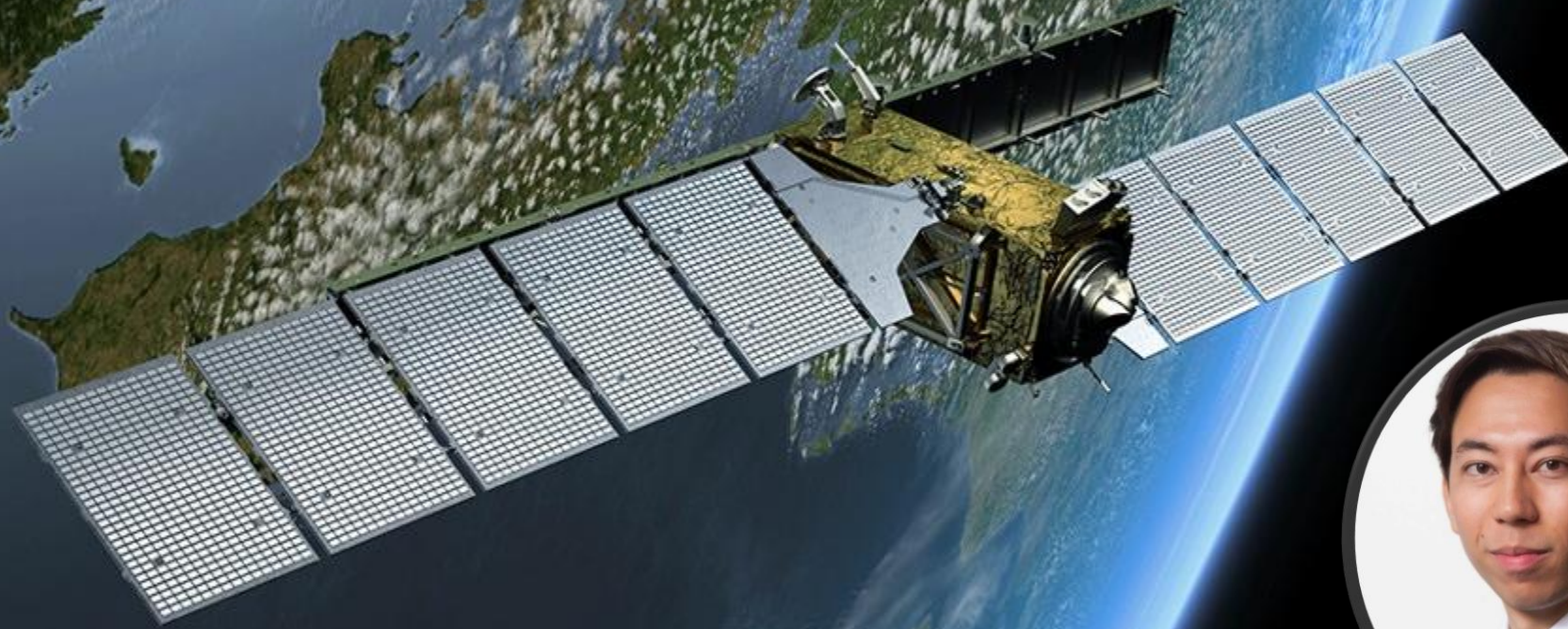
Main findings



- no correlation with socio-economic variables
- operational characteristics and ownership/rental models determine interest in electric vehicles
- anticipated cost savings increase interest

- individuals are the main agents of change in the informal transport sector
- driver unions should be included in the transition
 - in fragmented operator landscapes, they represent powerful levers to upscale the use of EVs
- policymakers should better communicate the financial benefits of operating EVs
- incentivize their purchase (e.g., through subsidies, regulatory privileges, or financing models)
- and provide charging infrastructure at parking hotspots

THANK YOU FOR YOUR ATTENTION



marc.hasselwander@dlr.de