Electric vehicle uptake in New Zealand: A spatio-temporal analysis*

Electric vehicles, urban development and energy infrastructure: comparative perspectives from the UK and South Korea Workshop

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* This presentation is largely based on Sheng, M. S., Wen, L., Sharp, B., Du, B., Ranjitkar, P., & Wilson, D. (2022). A spatio-temporal approach to electric vehicle uptake: Evidence from New Zealand. *Transportation Research Part D: Transport and Environment*, 105, 103256. doi:10.1016/j.trd.2022.103256

Outline

- Overview of New Zealand's emission profile, fleet status, and current EV programs and public charging facilities
- Hypothesis, data and variables
- Methodology
- Empirical results and robustness check
- Conclusion and policy implication

Overview

- Transport sector:
  - a main component of CO_2 emissions
- Critical long-term challenge worldwide:
  - 20% of global energy
  - > One-quarter of the overall energy-related CO_2
  - Road transport: three-quarters of total transport emissions
- NZ's unique emissions profile:
  - NZ's gross GHGs = 80.9 Mt CO_2-e in 2019 = 2.2% increase from 2018, increase from road transport
  - Two largest emitters in 2020: Agriculture (50%) & Energy (40%)
  - Road transportation – 38% of total emissions from the energy sector

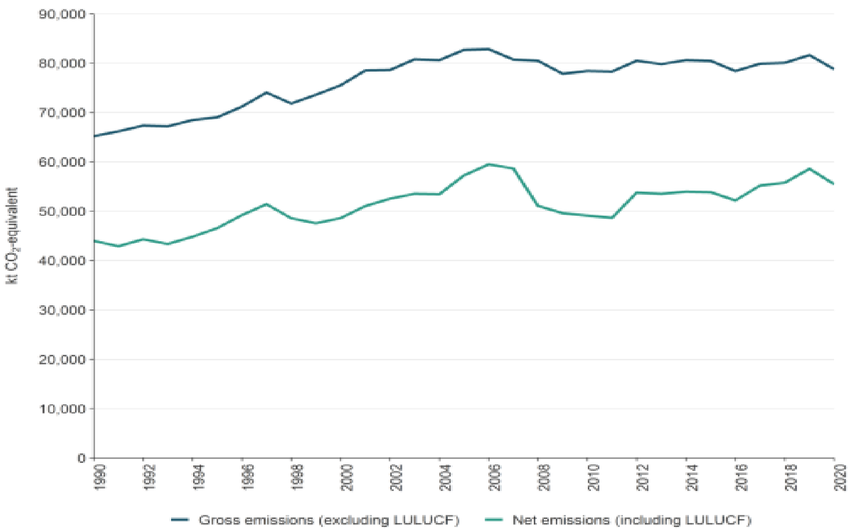

Fig. 1. NZ's gross and net emissions from 1990 to 2020, 23%+ (MfE, 2022)

Fleet status

- NZ imports all vehicles from overseas
- Pure EVs = the largest share in the vehicle market (Fig. 2)
- Used EVs are more popular compared to new EVs (Fig. 3)

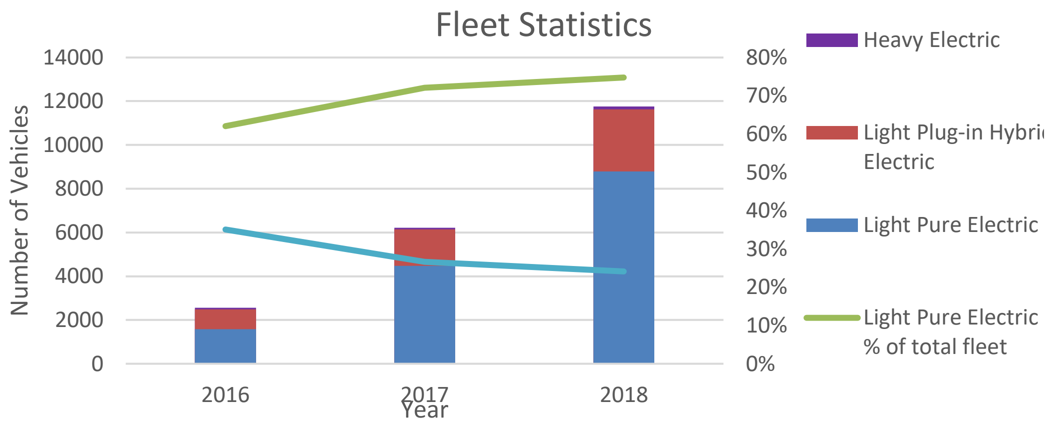

Fig. 2. Electric Vehicle Fleet Statistics, 2016 – 2018 (Vehicle Fleet Statistics, 2019)

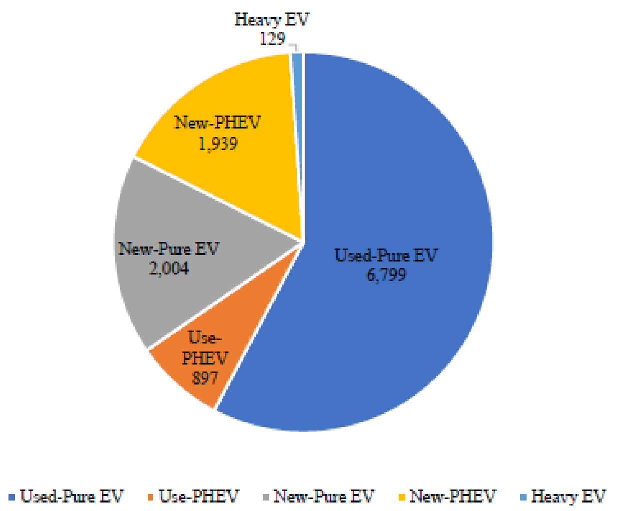

Fig. 3. Fleet Composition - 2018 (Vehicle Fleet Statistics, 2019).

Current EV programs

- The Ministry of Transport: EV program in 2016, with the aim to provide a broad set of fiscal initiatives and non-fiscal initiatives
- NZ passed the Climate Change Response (Zero Carbon) Amendment Act bill in 2019
- Govt: Clean Car Package in June 2021. The highlight of this package: post-purchase rebate scheme that applies to both new and used EVs under $80,000 from July 2021.

Public charging facilities

- > 500 public charging stations,

no more than 80 km apart

- 252 public DC fast chargers
- Tesla: Superchargers; slower chargers

at destinations

- Electricity companies (i.e., Vector)
- Hotels/motels/campgrounds offer

charging (Blue Commando plug)

- Wellington City Council:

street pole chargers for residents who only

have on-street parks.

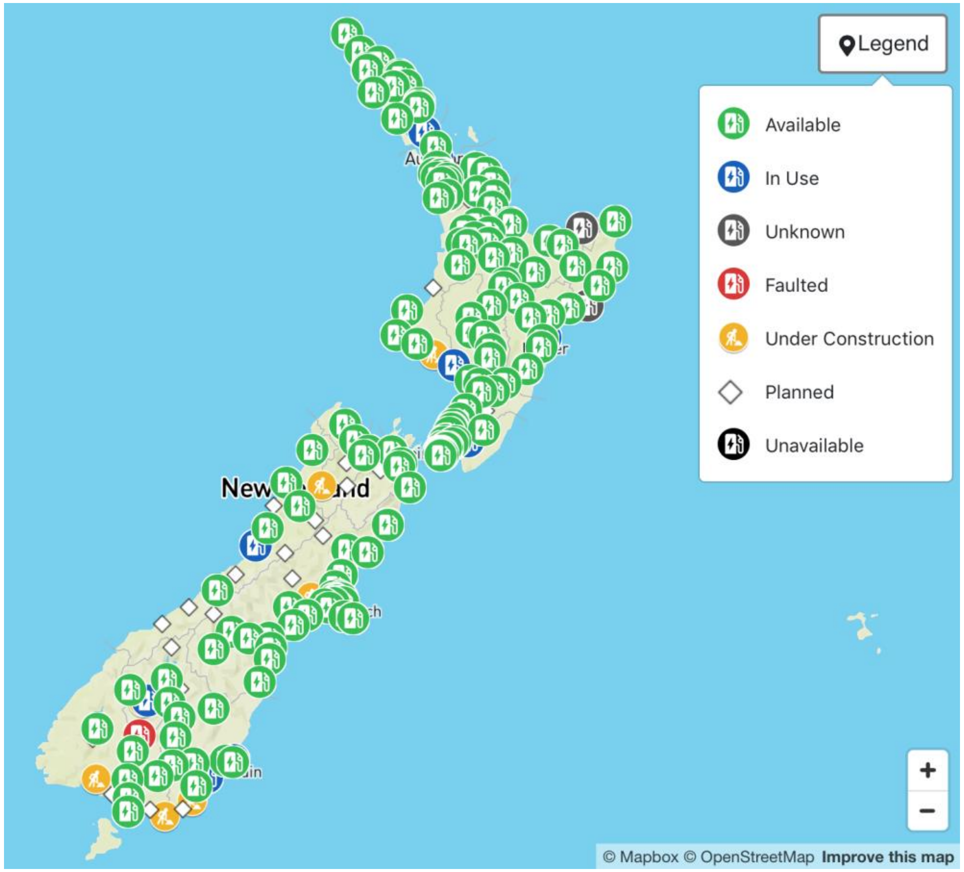

Fig. 4. Current map of ChargeNet chargers in NZ (2022)

Hypotheses

- **Hypothesis 1**

EV-charging infrastructure in the neighbouring areas has a positive and significant impact on EV uptake.

- **Hypothesis 2**

Early adoption has an overall positive effect on subsequent technology adoption: the lagged EV adoption has a statistically significant positive/negative value depending on neighbours' perception from observing or communicating with their neighbours who own EVs.

Data

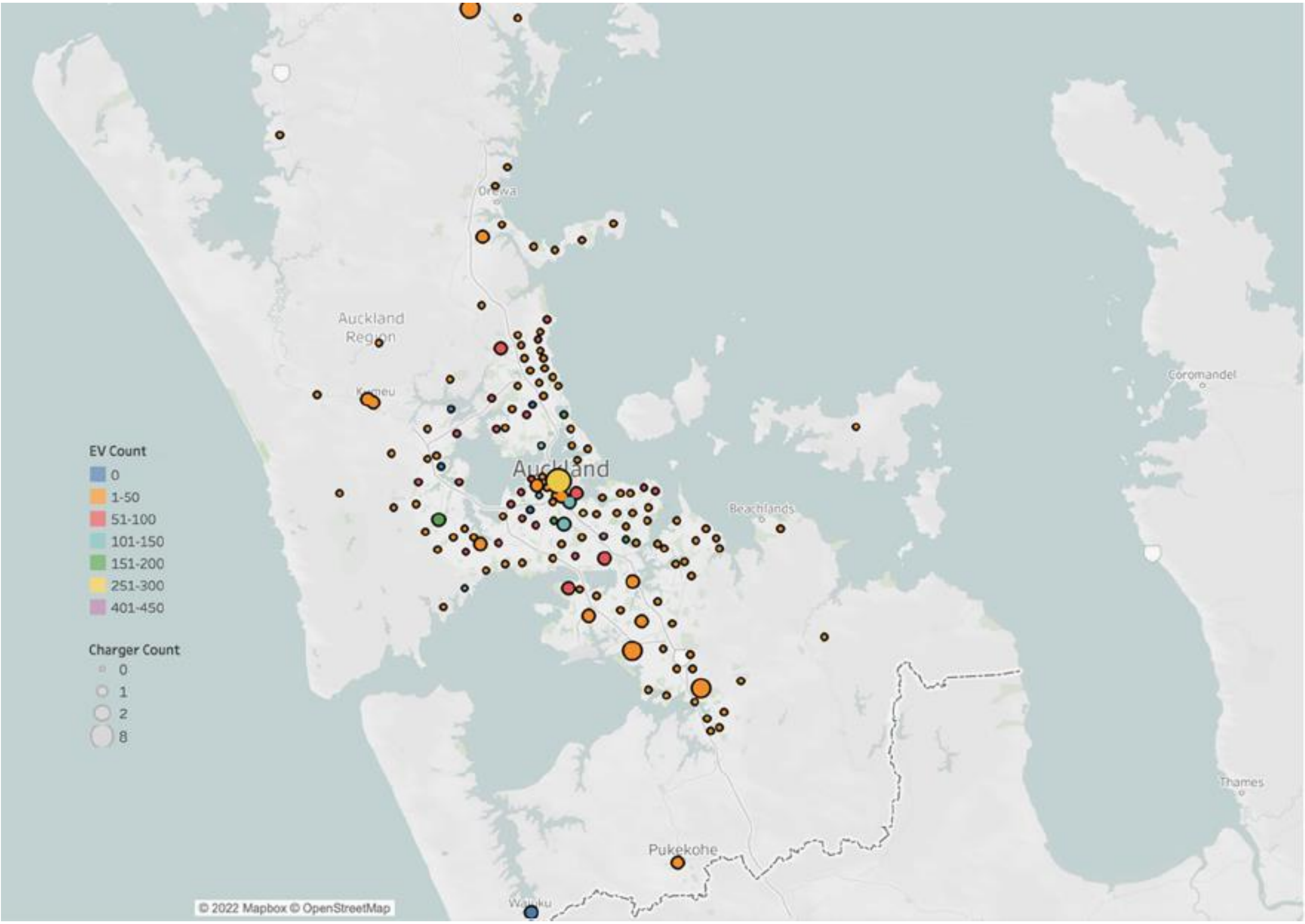

Fig. 5. Geographic Distribution of the Data (Authors' own illustration).

Variables

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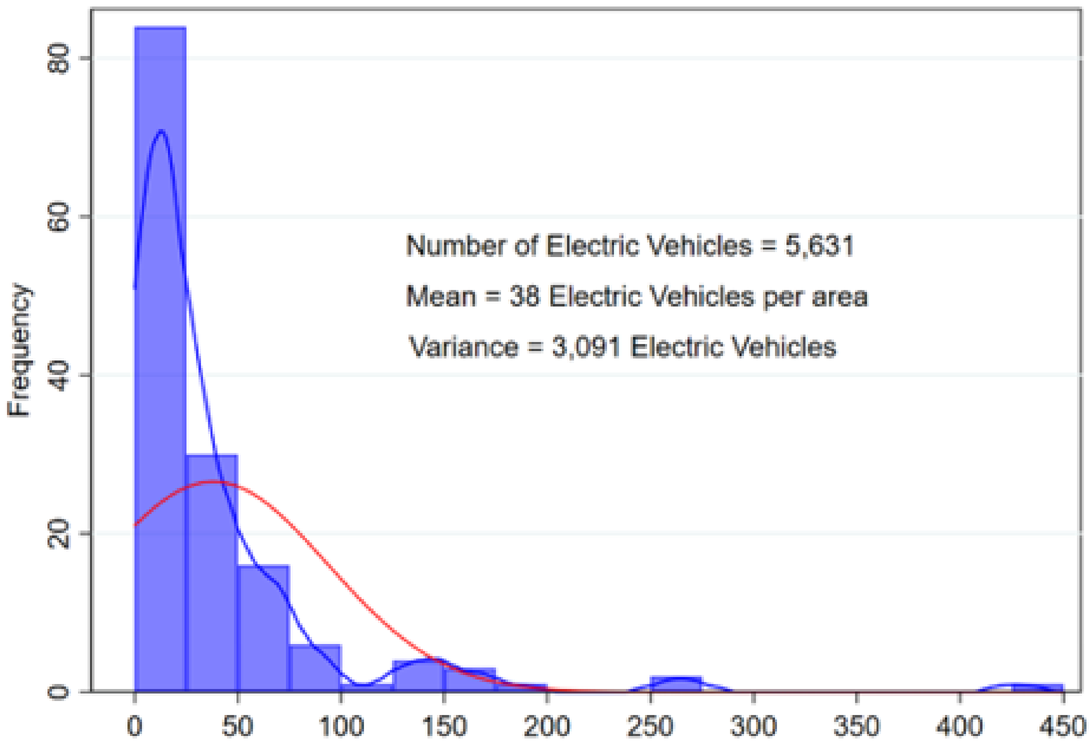

Fig. 6. Number of EV Adoptions (2020).

Main factors

- *Availability of Public chargers (2018 & 2020)*
- *Distance to CBD*
- *Transport mode*
- *Vehicle ownership*
- *Social and economic factors*

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Econometric model -1

- **The Poisson model** states that the probability that the dependent variable Y will be equal to a certain number y is:

$$p(\mathrm{Y} = \mathrm{y}) = \frac{e^{-\mu}\mu^{y}}{y!}$$

Where μ is the intensity or rate parameter:

$$\mu = \exp(\mathrm{x}_i^{'}\beta)$$

- **The negative binomial model** has a less restrictive property that the variance is not equal to the mean

$$\mathrm{var}(y \mid x) = \mu + \alpha\mu^{2}$$

When α>0, overdispersion. – test if α is significantly different from 0.

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Econometric model -2

- Spatial model

$$Y = X\beta + \boxed{W}X\gamma + \varepsilon$$

- Spatial weight matrix

$$W = \begin{pmatrix} 0 & w_{12} & w_{13} & w_{14} & \dots & w_{1n} \\ w_{21} & 0 & w_{23} & w_{24} & \dots & w_{2n} \\ w_{31} & w_{32} & 0 & w_{34} & \dots & w_{3n} \\ w_{41} & w_{42} & w_{43} & 0 & \dots & w_{4n} \\ \dots & \dots & \dots & \dots & 0 & \dots \\ w_{n1} & w_{n2} & w_{n3} & w_{n4} & \dots & 0 \end{pmatrix}$$

W - a n x n matrix.
The non-diagonal elements w_{ij} reflect the spatial influence of area *i* on area *j*.
The diagonal elements w_{ii} are set to zero to exclude self-influence.

$$\mu_i^{**} = \exp(EV18_i\gamma_{ev18} + WEV18_i\theta_{ev18} + CHAR_i\gamma_{char} + WCHAR_i\theta_{char} + x_i\beta + \nu_i)$$

Empirical results

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	Model 1 Non-spatial model		Model 2 Spatial model	
VARIABLES	Coefficient	Incidence rate (IRR)	Coefficient	Incidence rate (IRR)
Main factors				
Hypothesis (H1):				
Public chargers	0.133	1.143	0.215	1.240
	(0.179)		(0.184)	
WX-Public chargers	/		2.706**	14.977
	/		(1.380)	
Hypothesis (H2):				
Total EV in 2018	0.034***	1.034	0.033***	1.034
	(0.005)		(0.009)	
WX-Total EV in 2018	/		-0.060*	0.942
	/		(0.034)	
Distance to CBD	-0.013***	0.987	-0.028***	0.972
	(0.005)		(0.010)	
Two vehicles	0.005**	1.005	0.004**	1.004
	(0.002)		(0.002)	
High qualification	0.030*	1.031	0.031**	1.031
	(0.017)		(0.015)	
Other control variables	Yes		Yes	

Robustness check

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	Model 3 (band=5km)		Model 4 (band=100km)	
VARIABLES	Coefficient	Incidence rate (IRR)	Coefficient	Incidence rate (IRR)
Main factors				
Hypothesis (H1):				
Public chargers	0.157	1.153	0.273	1.314
	(0.185)		(0.183)	
WX-Public chargers	0.139**	1.213	4.310***	74.460
	(0.070)		(1.232)	
Hypothesis (H2):				
Total EV in 2018	0.031***	1.032	0.033***	1.034
	(0.005)		(0.009)	
WX-Total EV in 2018	-0.005*	0.993	-0.081**	0.922
	(0.001)		(0.032)	
Distance to CBD	-0.020***	0.982	-0.048***	0.953
	(0.007)		(0.011)	
Two vehicles	0.004*	1.004	0.004**	1.004
	(0.002)		(0.002)	
High qualification	0.041***	1.037	0.031**	1.023
	(0.015)		(0.015)	
Other control variables	Yes		Yes	

Conclusion and policy implications

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- Better designed public charging infrastructure
  - public-private partnership model
- Transport planners could tailor incentive programs to target the uptake of EVs by early adopters.
- Numerous policy initiatives exist and span
  - financial assistance, such as EV subsidies and taxation benefits
  - non-financial opportunities, such as fostering urban charging initiatives
- Behaviour change programs
  - highlighting EV purchase as new social norms
  - promoting EV ownership benefits
  - combined with other forms of support for home efficiency improvements, such as technology demonstration and related education programs.

Other transport works (2021-2022)

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1) Majhi, R.C., Ranjitkar, P. & **Sheng, M.** (2022). Assessment of dynamic wireless charging based electric road system: A case study of Auckland motorway. Sustainable Cities and Society, 84, 104039. https://doi.org/ 10.1016/j.scs.2022.104039
2) **Wen, L.,** Sharp, B., Suomalainen, K., **Sheng, M**., & Guang, F. (2022). The impact of COVID-19 containment measures on changes in electricity demand. *Sustainable Energy Grids and Networks*, 29, 100571. https://doi.org/10.1016/j.segan.2021.100571
3) Suomalainen, K., **Wen, L., Sheng, M.** & Sharp, B. (2022). Climate change impact on the cost of decarbonisation in a hydro-based power system. *Energy*, 246(1), 123369. https://doi.org/10.1016/j.energy.2022.123369
4) Majhi, R.C., Ranjitkar, P. & **Sheng, M.** (2022). Dynamic wireless charging facility allocation on a road network for electric vehicles. *Transportation Research Part D: Transport and Environment* (revised & resubmitted).
5) Pan, A. and **Sheng, M**. (2022). The Complementary Duet of Vehicular Diverging: An Experimental Approach. *Case studies on Transport Policy* (under review).
6) **Sheng, M.**, Du, B., Sreenivasan, A.V., Raith, A. & Sharp, B. (2022). *Optimal Deployment of Dynamic Wireless Charging Infrastructure for Electric Bus Operation*. Working paper.
7) **Wen, L., Sheng, M**., Suomalainen, K, Sharp, B., Meng, M., Du, B. & Yi, M. (2022). Solar potential and the uptake of Electric Vehicles: Some Evidence from New Zealand. (submitted to *Energy Policy*)
8) Guest, W., Lu, C., Zorn, C., **Sheng, M**. & **Wen, L.** (2022). *Feasibility of Diesel-Hybrid Trucks in New Zealand*. Working paper.
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Thank you!

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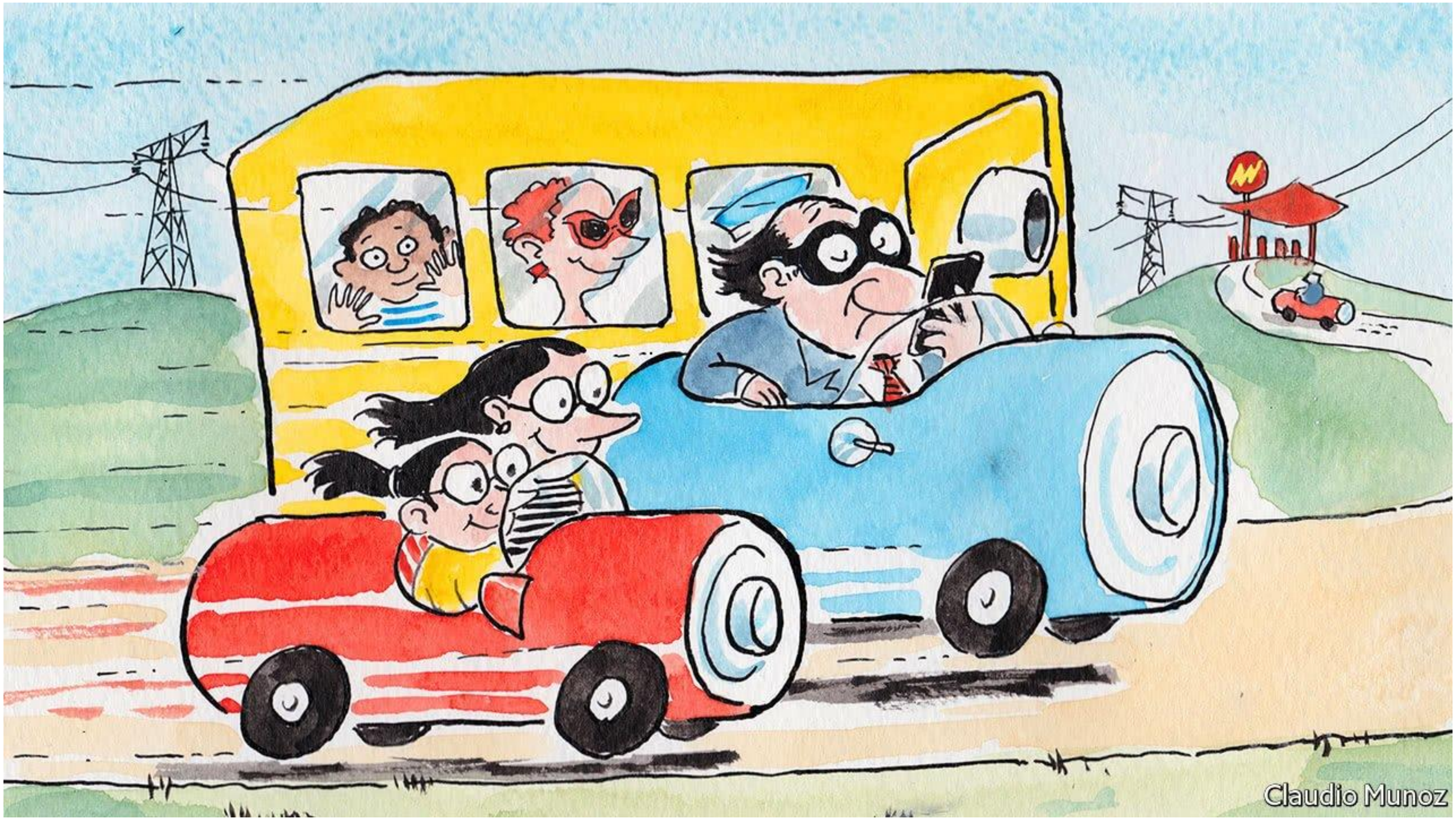

Source: The Economist, 2017

Questions?