Factors Influencing the Diffusion of Electric Vehicles in China

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Outline

- Motivation
- Research question and hypotheses
- Data and policies
- Results
- Conclusion

Motivation

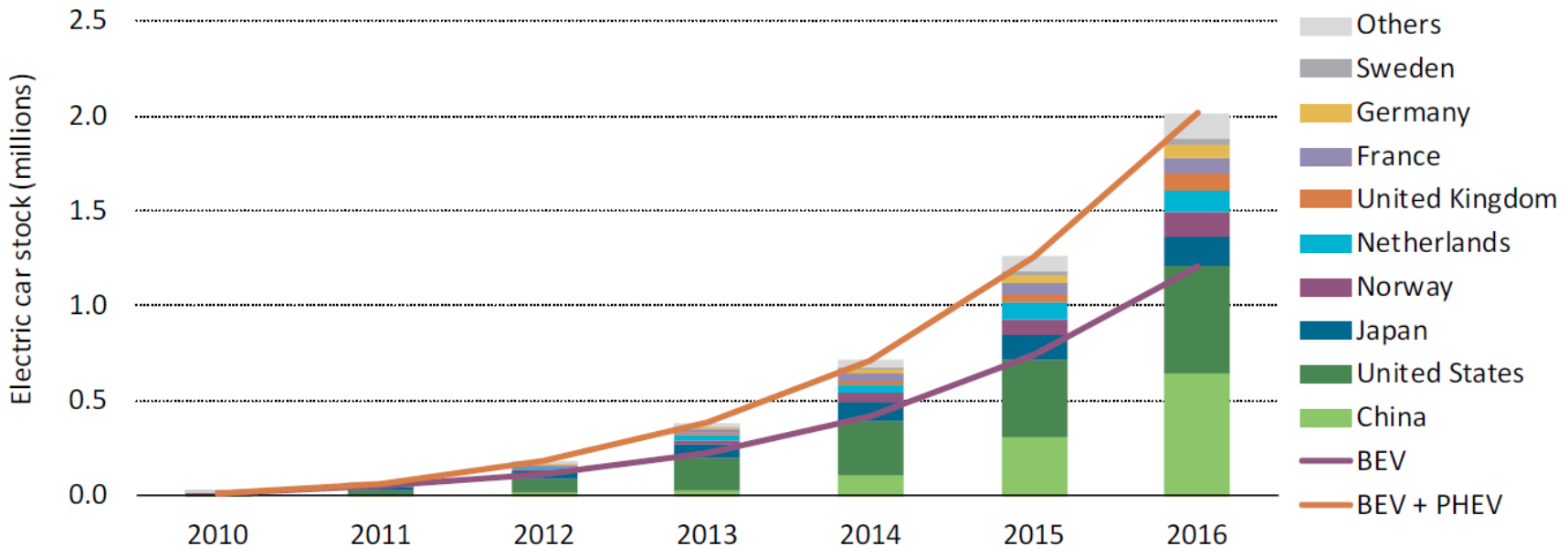
Greening the transport sector

Motivation

- *"…transport sub-sectors currently produce almost one quarter of total global energy-related CO_2 emissions…"* (Sims et al. 2014 [IPCC, Ch. 8])
- **Decarbonizing transport**, especially passenger transport, key to mitigate climate change and fulfil the sustainable development goals
- Electric vehicles possible way to **reduce local and global emissions** from passenger transport (esp. with green electricity) (Sperling 2018)
- However, electric vehicles account for **only 0.2% of all passenger light-duty vehicles** (IEA 2017)

Motivation

Figure 1 • Evolution of the global electric car stock, 2010-16



Notes: The electric car stock shown here is primarily estimated on the basis of cumulative sales since 2005. When available, stock numbers from official national statistics have been used, provided good consistency with sales evolutions.

Sources: IEA analysis based on EVI country submissions, complemented by EAFO (2017a), IHS Polk (2016), MarkLines (2017), ACEA (2017a, 2017b) and EEA (2017).

Source: IEA (2017)

Motivation

- Increasing the share of electric vehicles is a classical **diffusion process** (Geroski 2000, Hall 2006)
- However, there is **competition between two technologies**: the stablished internal combustion engine and the emerging electric vehicles (Arthur 1989, Cowan/Hulten 1996)
- We are currently locked-in into a **carbon based mobility system** (Unruh 2000, 2002)
- The lock-in is enforced by a **double externality problem** (Rennings 2000, Jaffe/Stavins 2005)
- Escaping the lock-in requires governmental intervention

Motivation

- China is currently the **global forerunner** in electric vehicle diffusion (IEA 2017)
  - In 2016, China accounted for 40% of global electric car sales
  - China also has the largest electric car stock of one third of global electric cars in 2016
  - The largest fleet with over 300.000 electric busses is also in China

- China implemented a **comprehensive policy mix** supporting the diffusion on the national and local level (Wang et al. 2017a)

- Electric vehicle policies are in line with Chinas aims to **reduce emissions** and improve local air quality (Ma et al. 2017, Wang et al. 2017a)

- China is an ideal case to **study factors influencing the diffusion** of electric vehicles

Research question and hypotheses

How do we get there?

Research question

- The diffusion of electric vehicles is from a sustainable perspective a desirable process
- Diffusion is hampered due to lock-ins and other externalities
- Different policy intervention are implemented, supporting the diffusion
- However, diffusion of electric vehicles still very low

RQ: Which factors influence the diffusion of electric vehicles?

Hypotheses

- H1**: Financial purchase incentives** increase diffusion
  - Cantono/Silverberg (2009) show in a theoretical model that subsidies can increase diffusion
  - Jenn et al. (2013) find mixed evidence on the effect of federal incentives on the adoption of hybrid electric vehicles in the United States
  - Hardman et al. (2017) review the literature on financial purchase incentives for electric vehicles and find that well-targeted incentives increase diffusion

- H2: **Regulatory incentives** increase diffusion
  - Ma et al. (2017) show that the abolishment of restriction on traffic for electric vehicles in Chinese cities increase diffusion
  - Gallagher/Muehlegger (2011) find mixed evidence for the correlation with the allowance to use high occupation lines for electric vehicles and their diffusion
  - Wang et al. (2017b) finds a strong effect of license plate lotteries and no driving restriction on electric vehicle diffusion in Chinese regions

Hypotheses

- H3: Availability of **complementary infrastructure** increase diffusion
  - Rosenberg (1972) discusses the importance of complementary innovations and infrastructure to increase diffusion
  - Several studies find a strong correlation between the presence of charging infrastructure and electric vehicle diffusion (e.g. Sierzchula et al. (2014), Vergis/Chen (2015), Mersky et al. (2016))

- H4: **Bad environmental conditions** increase diffusion
  - Cantono/Silverberg (2009) show that customers are willing to pay a “green” premium
  - Hidrue et al. (2011) find that environmental concerns hardly influence consumer decisions to buy electric vehicles

Data and policies

What can we measure?

Data

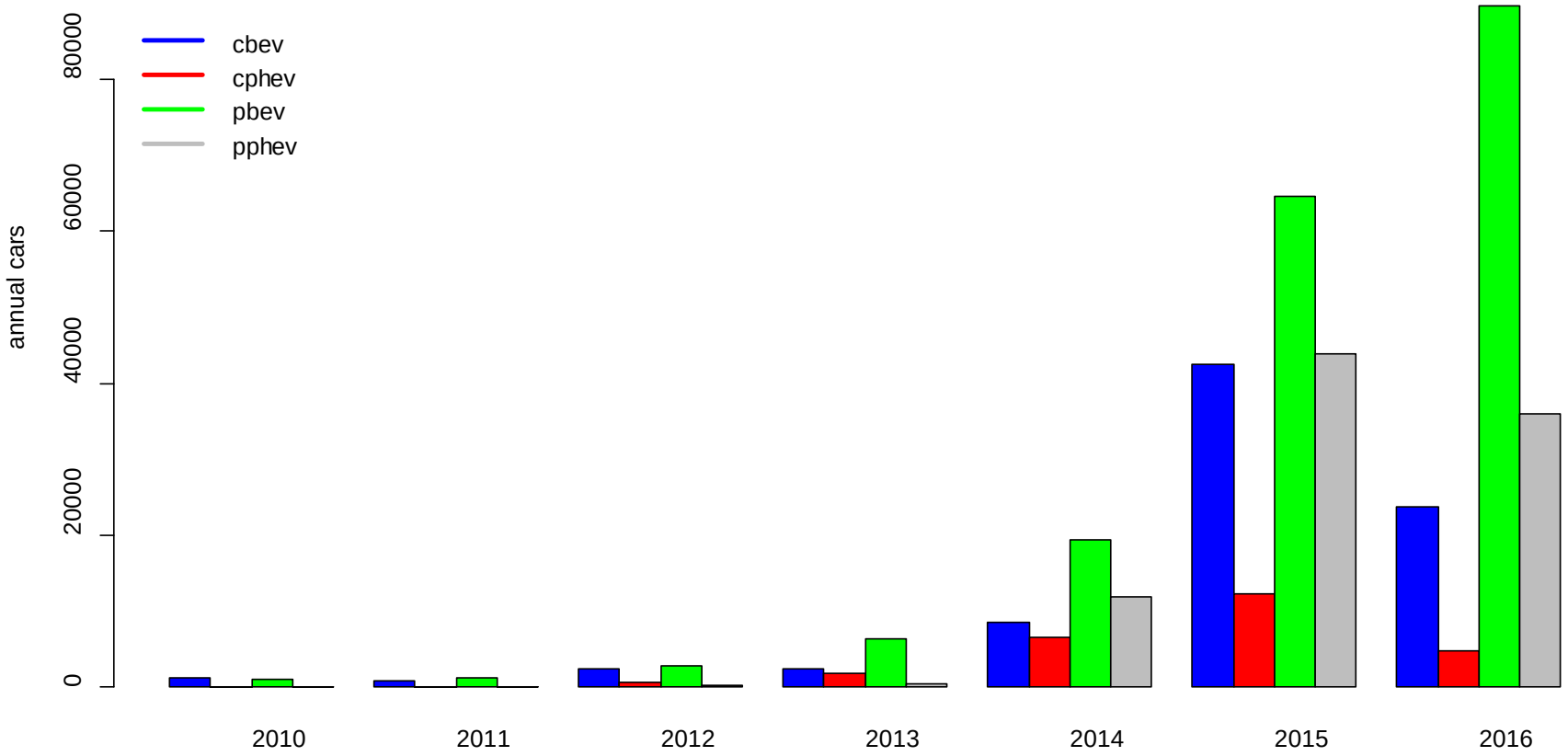
- Data sources:
  - Yearbook of Energy-Saving and New Energy Vehicles, (ed. 2010-2016)
  - Statistical Yearbook of regions, (ed. 2010-2016)
  - Environment Bulletin of regions, (ed. 2010-2016)

- Unbalanced panel
  - 34 geographical units (cities, regions, municipalities)
  - 7 Periods (2010 until 2016, however, lots of missing data)
  - Econometrically challenging (missing data, endogeneity)

- Four types of electric vehicles
  - Battery electric vehicles (BEV)
  - Plug-in hybrid electric vehicles (PHEV)
  - Commercial vehicles (busses)
  - Passenger cars

	BEV	PHEV	
Commercial			
Passenger			

Annual new vehicles



Policies

- National policies and strategies (see Zhang/Bai 2017 or Zhang et al. 2017 for details)
  - Since the 8th Five-Year Plan (1990-1995), electric vehicle R&D and establishing an electric automobile industry high on the agenda
  - 2009: “Ten Cities, Thousands of EVs” subsidy program, vastly extended over time
  - 2012: “Development plan for the new-energy automobile industry (2012 - 2020)”
  - 2012: Tax incentives for purchasing electric vehicles
  - Aim to reduce subsidies over time and create self-sustaining markets
  - Support policies to establish charging infrastructure

- Heterogeneous regional policies
  - Subsidies on the regional level to complement national policies
  - Different regional strategies: Shanghai supports BEV and PHEV while Beijing supports only BEV due to regional protectionism of local firms (Wang et al. 2017a)
  - Regional car-ownership policies (exception from license plate lottery or auction)

Policy Variables

- Financial purchase incentives
  - Subsidies are conditioned on vehicle characteristics, we take average subsidy level
  - Overall subsidy
  - National level (participation in the ten cities program)
  - Regional level
- Non-monetary incentives
  - License plate lotteries
  - Only in 5 cities implemented
- Charging Infrastructure
  - Cumulative number of charging possibilities
  - Differentiation between charging/swapping stations and charging points

Environemntal Variables

- China “famous” for its polluted cities
  - Emissions from conventional automobiles are key factors (Colvile et al. 2001, Wang et al. 2009, Yang/He 2016)
  - Regional differences exist, depending on industry structure
  - Huo et al. (2015) show that mitigation due to electric vehicles in cities depends on share of coal based electricity

- Indicators to capture environmental condition
  - PM10 particles are emitted by the transport sector and cause major health issues
  - PM10 concentrations are measured on a daily basis and averaged per year
  - Air Quality Index as a composite indicator (SO2, NO2, O3, CO, PM10 and PM2.5)
  - Days of air quality equal to or above Grade II (good days)
  - Composition of Air Quality Index and measurement changed in 2013

Results

How is diffusion influenced?

Econometric setup

- OLS-Panel regression with year and regional fixed effects

- Four dependent variables:
  - Log of annual commercial BEV
  - Log of annual commercial PHEV
  - Log of annual passenger BEV
  - Log of annual passenger PHEV

	BEV	PHEV	
Commercial			
Passenger			

- Four independent variables of interest
  - Total government subsidies
  - Log of cumulative charging stations
  - Dummy for License plate lottery
  - Pollution level (PM10)

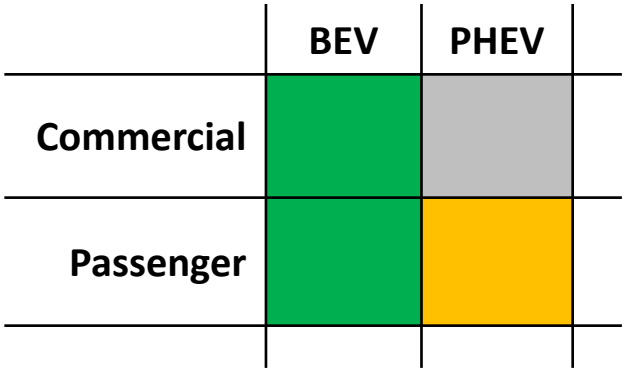
- Four control variables
  - Log GDP, Log population, relative education level, consumer price index

Results

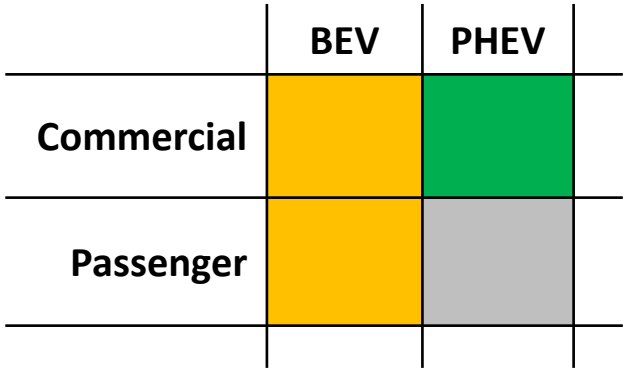
	CBEV	CPHEV	PBEV	PPHEV
GDP	-4.144	-3.062	-10.599 ***	-6.018 **
	(3.093)	(3.076)	(2.910)	(2.501)
Population	3.286	-2.494	-1.249	-2.897
	(4.362)	(4.213)	(3.643)	(3.059)
Education	0.351	0.122	-0.093	-0.271
	(0.244)	(0.354)	(0.311)	(0.310)
Conumer Price	-0.021	0.133	0.122	0.242 **
Index	(0.075)	(0.123)	(0.074)	(0.116)
Total Subsidies	0.003 ***	-0.001	0.016 **	0.011
	(0.001)	(0.002)	(0.006)	(0.006)
Charging Stations	-0.105	0.464 ***	-0.099	0.155
	(0.187)	(0.156)	(0.193)	(0.172)
License plate			-0.588	2.072 ***
lottery			(0.833)	(0.756)
PM10 Pollution	0.008	0.008	-0.023 **	-0.021 **
	(0.012)	(0.013)	(0.010)	(0.010)
R2 (within)	0.006	0.009	0.002	0.002
Adj R2 (within)	-0.389	-0.382	-0.406	-0.407
n	31	31	32	32
T	7	7	7	7
N	152	153	156	156
df	108	109	110	110

Results

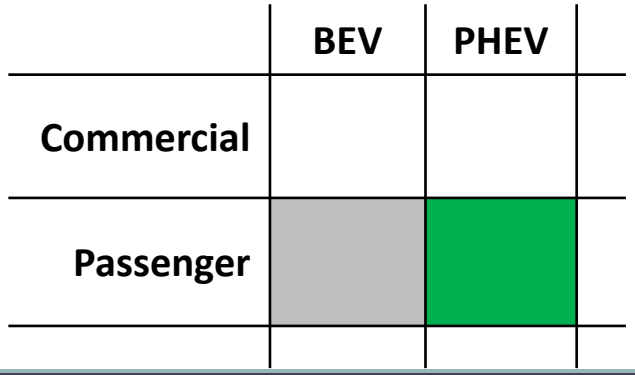
- H1: **Financial purchase incentives**



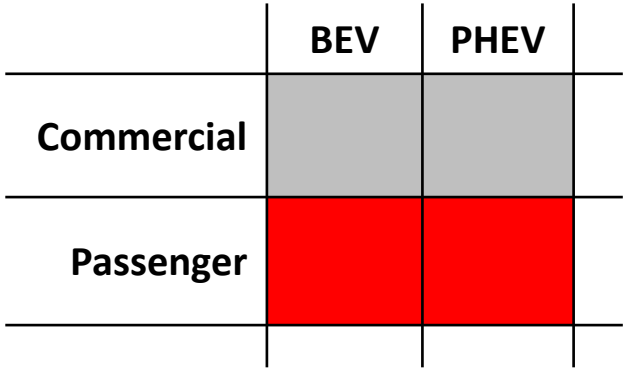
H3: **Complementary infrastructure**



- H2: **Regulatory incentives**



H4: **Bad environmental conditions**



Conclusion

Greening the transport sector

Conclusion

- More differentiated view on factors correlating with electric vehicle diffusion
  - Effects are different between vehicle types
  - Financial support especially relevant for BEVs
  - License plate lottery works only for PHEV, since they are a good substitute for conventional cars
  - Charging stations matter only for commercial vehicles, passenger vehicles maybe charged at home
- Environmental conditions lead to puzzling results, but maybe related to changing industry structure or data issues
- Policies need to be target precisely to the vehicle type and the local conditions (non-technological neutral policies)
- How should a policy mix look like?

Thank you!

I’m looking forward to your comments