A multi-model approach: international electric vehicle adoption

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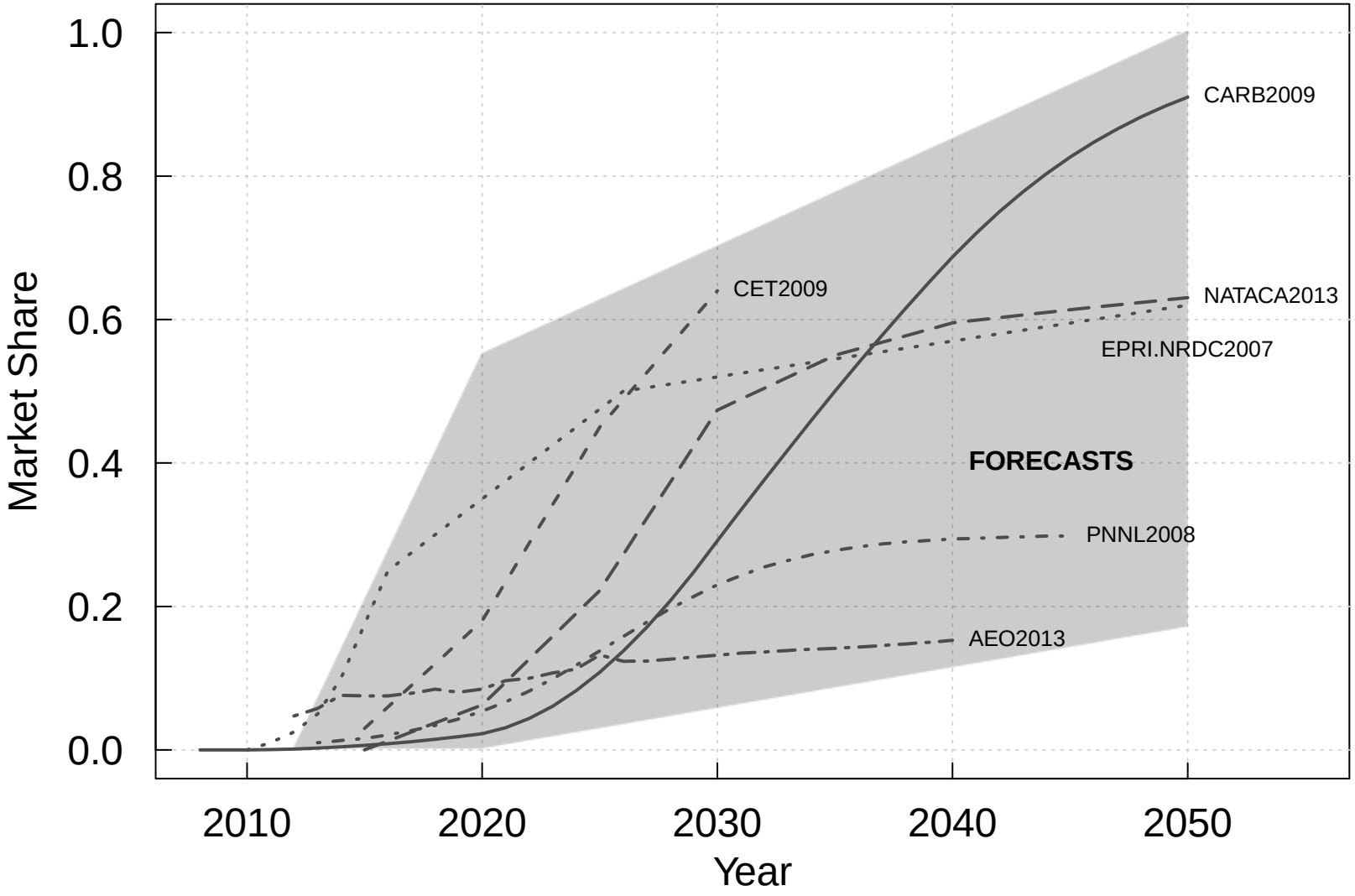
What will electric vehicle adoption look like in the future?

- The primary objective of this research is to investigate future international scenarios of electric vehicles (EVs) to 2030/2050. The broad set of questions we are interested in studying:
  - How many electric vehicles will be on the road in 2030? 2040? 2050?
  - When will we see 100 million EVs cumulatively in the world? Can this be achieved by 2030?
  - What sorts of vehicle pricing and attributes are required to boost adoption?
  - Which policies can be implemented in different countries to promote EVs in the most effective manner?

What is the future of electric vehicle adoption?



Using three different models for scenario

- How are different estimates effected by their choice of modeling technique as opposed to assumptions about inputs?
- We employ three very different models to test for the robustness of outcomes:
  - Discrete choice model
  - Technology diffusion model
  - Regression of trends

Discrete choice model

- We simulate consumers' decision making process about selecting a product among a set of discrete choices
- An individual is more "attractive" based on its comparative value compared to other vehicles
- Vehicle attributes inform "attractiveness"

Vehicle Brands

Fuel Efficiency

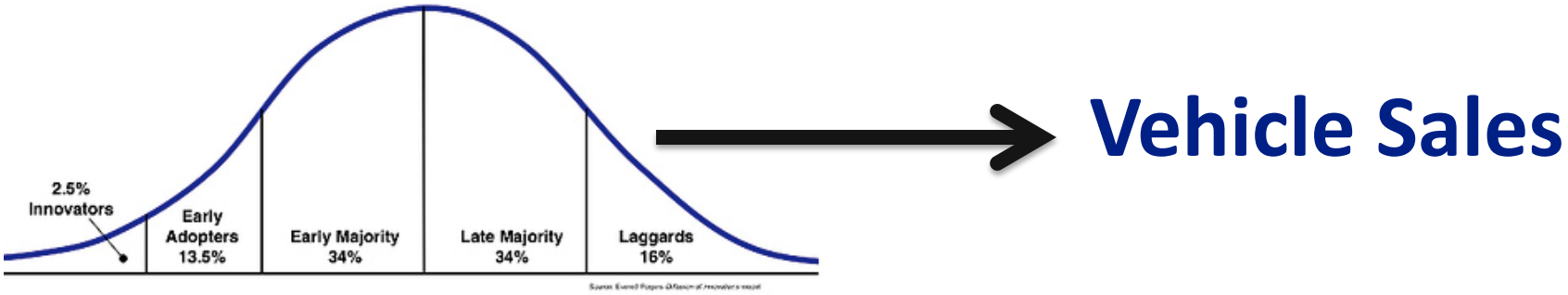
Engine Size, Power

Vehicle Classes

Vehicle Sales

Technology diffusion model

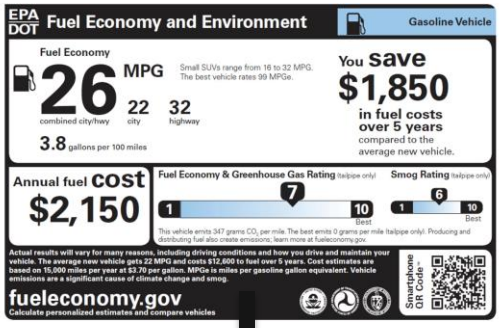
- Diffusion of innovation theory argues that most technologies are adopted under similar trends
- Vehicle projections are made based on how the trends can be fit against historical sales of electric vehicle technologies



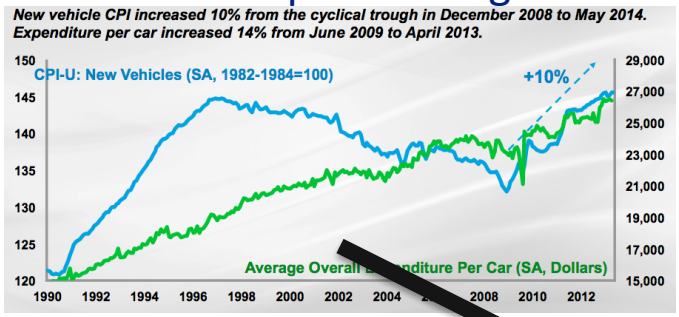
Regression of trends approach

- Regression of trends looks at how vehicle sales are effected across a number of factors that change over time
- The model includes both variables intrinsic to the vehicles (prices, efficiency) as well as external factors (gas prices, GDP)

Improvements in efficiency



Vehicle price changes



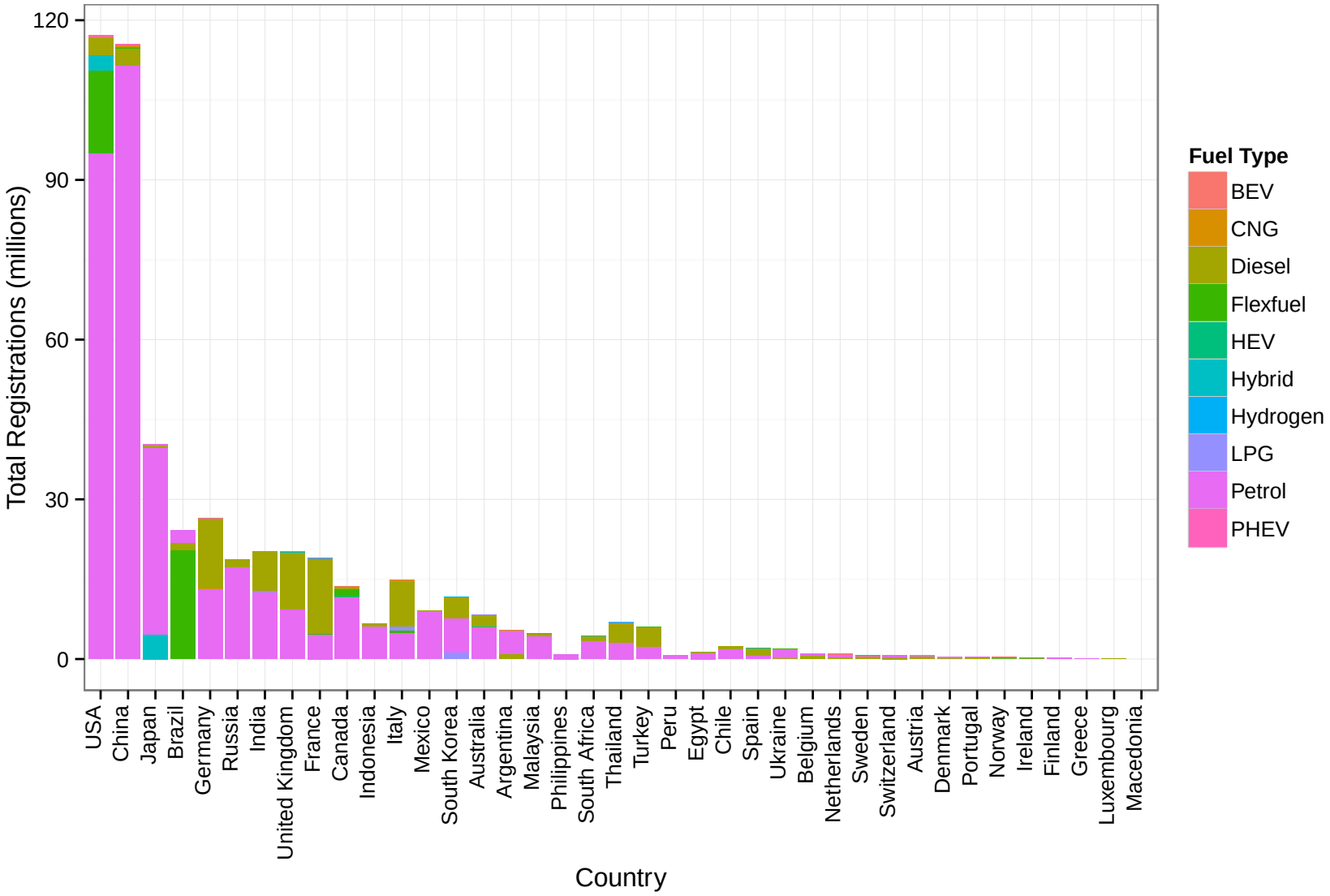
Gas prices

Vehicle Sales

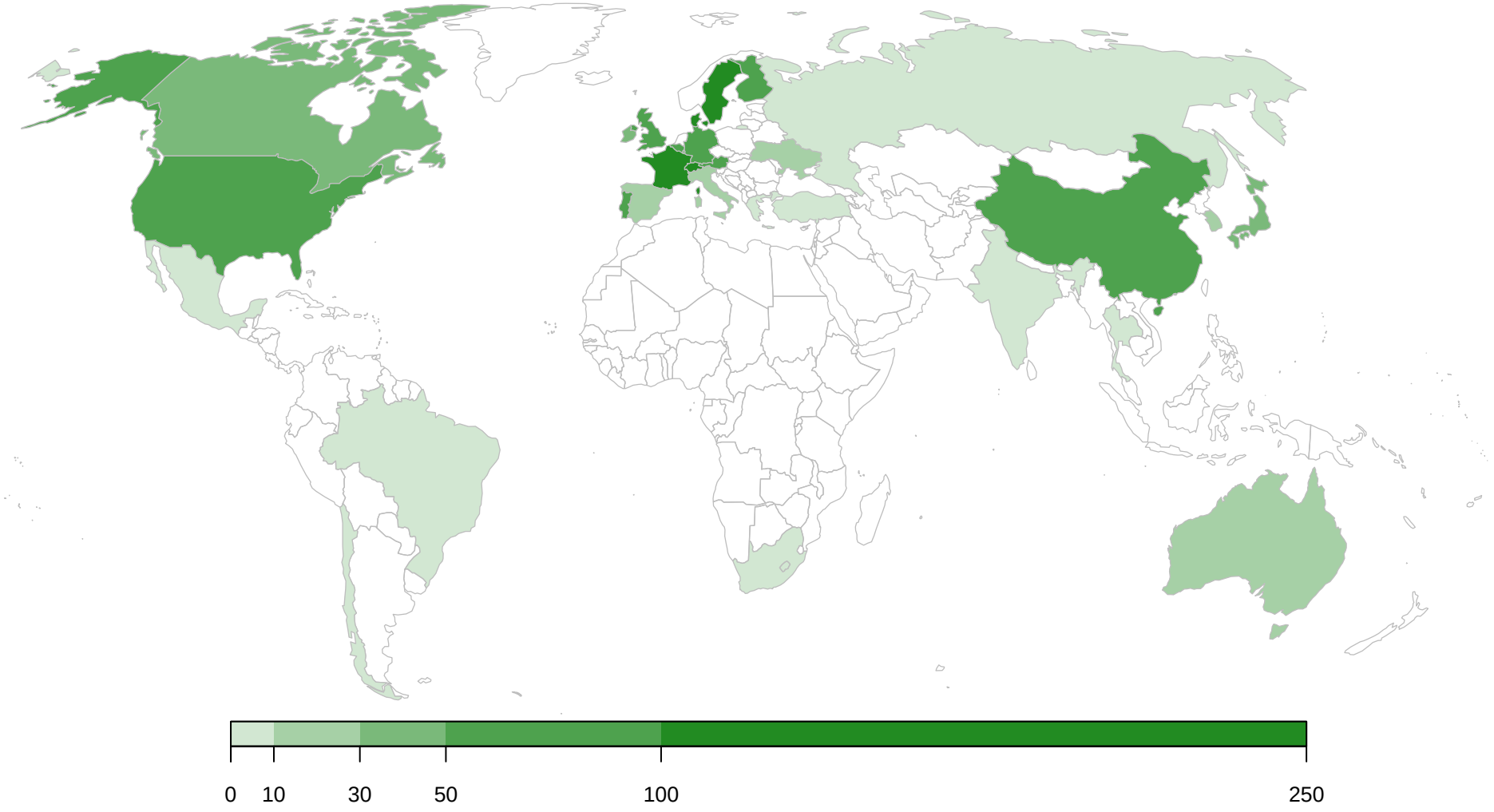
Our project leverages an extremely detailed dataset

- We are using a large dataset of new vehicle registrations from IHS Automotive.
- The data were cleaned and expanded in cooperation with the International Energy Agency.
- A quick summary of the dataset
  - Number of countries: 39
  - Years: 2005, 2008, 2010-2015
  - Unique vehicle models: 4,771
  - Unique vehicle manufacturers: 503
  - Total registrations: 509,194,651
  - Vehicle attributes: Axles, drive, engine size, # of cylinders, engine power, fuel type, transmission, turbo, price, segment, curb weight, footprint, fuel efficiency (NEDC/WLTP), and emissions (NEDC/WLTP)

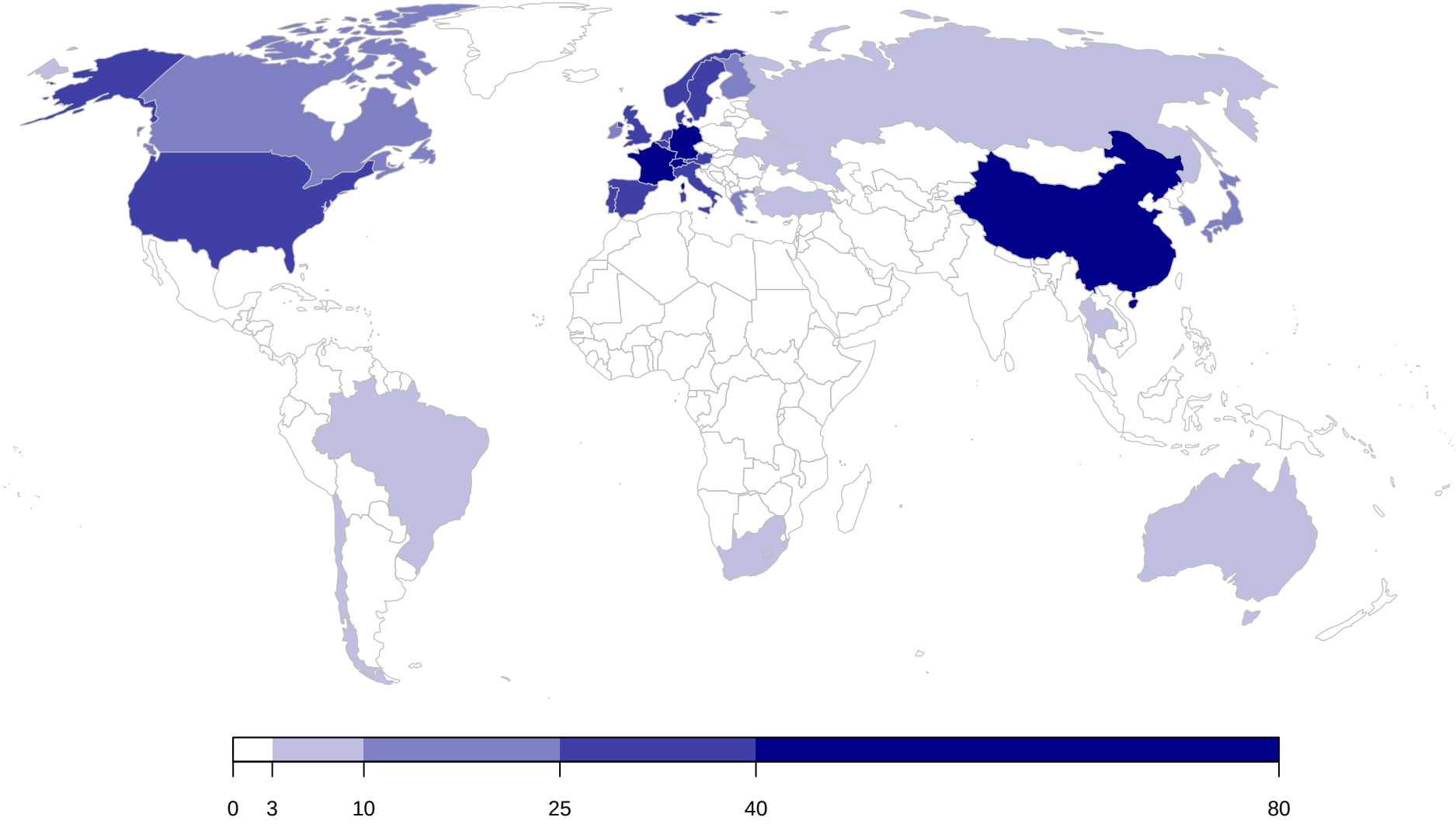
International vehicle registrations by fuel technology (cumulative 2010-2015)



Worldwide sales of electric vehicles
(EVs per 10000 conventional vehicles sold)

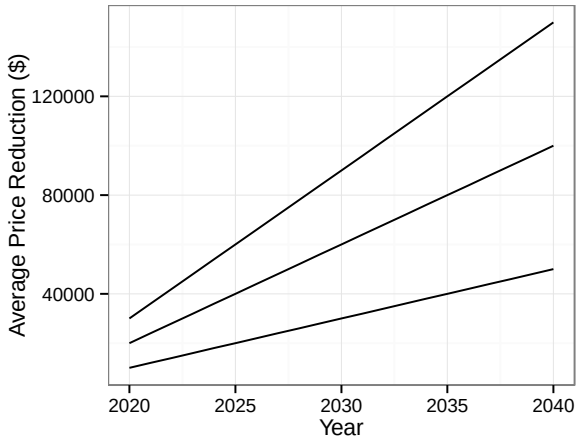


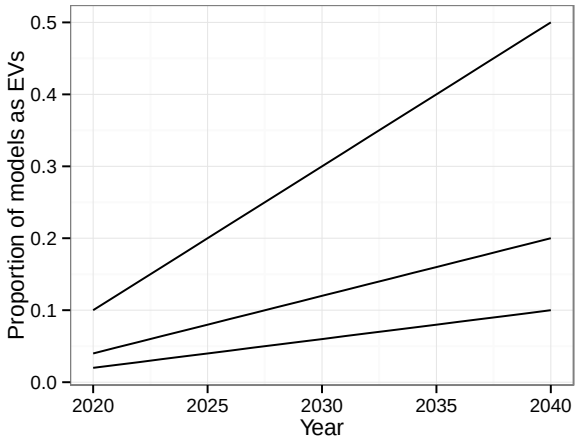
Number of electric vehicle models available

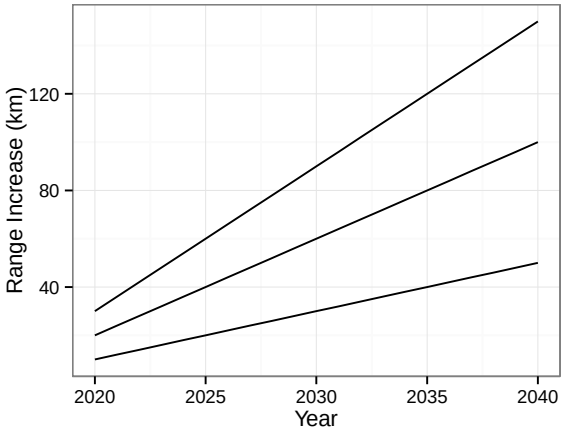


Assumptions for forecasting

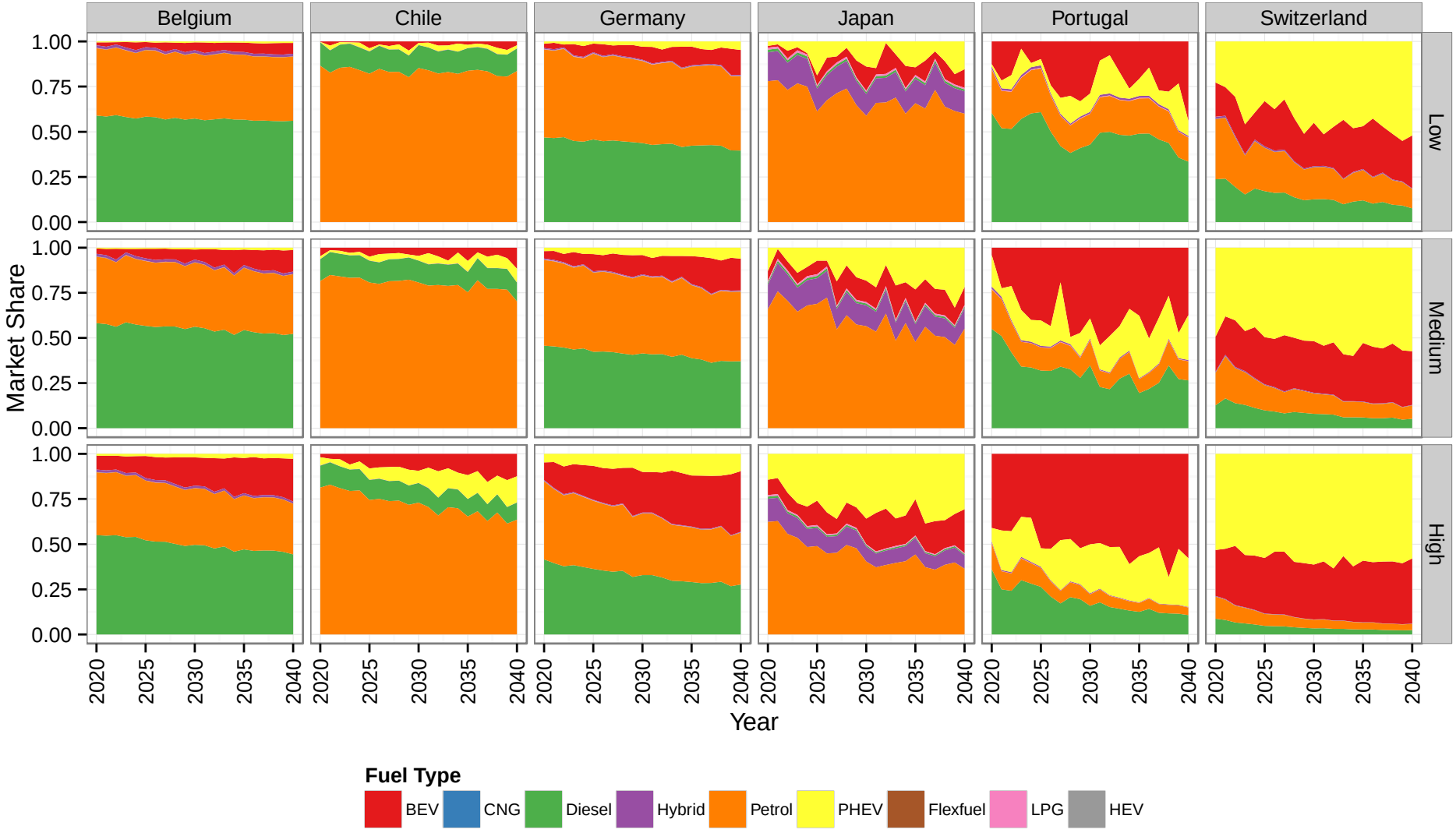
- We examine three basic scenarios for forecasting, each scenario assumes different prices and model availabilities for electric vehicles.
  - Price reductions are exogenous, their mechanisms are not explicitly stated but include learning-by-doing, competition, and policy incentives.
  - Model availability refers to the coverage of EVs in the market of vehicle models.
  - Range of EVs are increased over time to allay issues of range anxiety



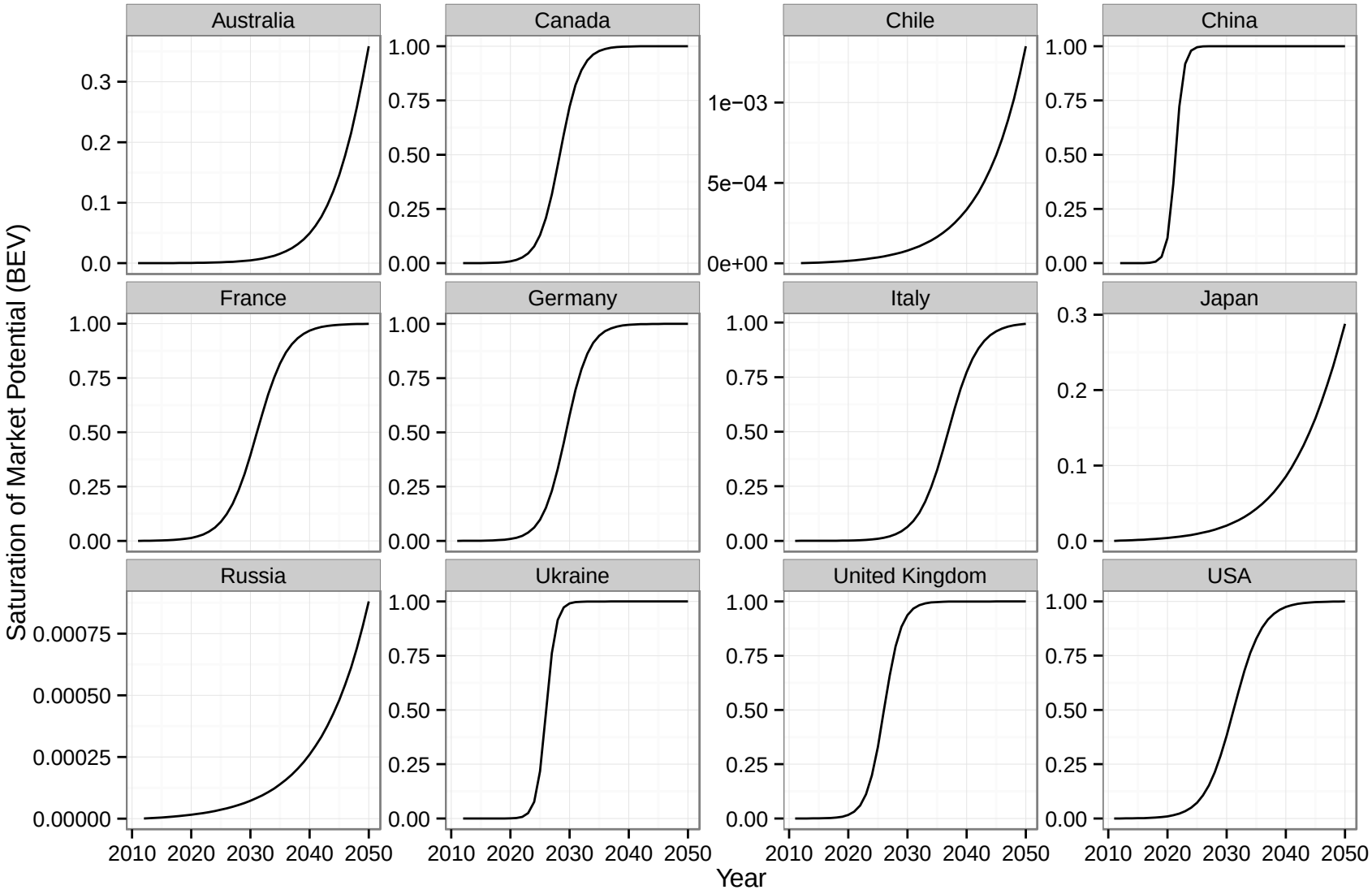




Sample of vehicle scenario projections using discrete choice modeling approach

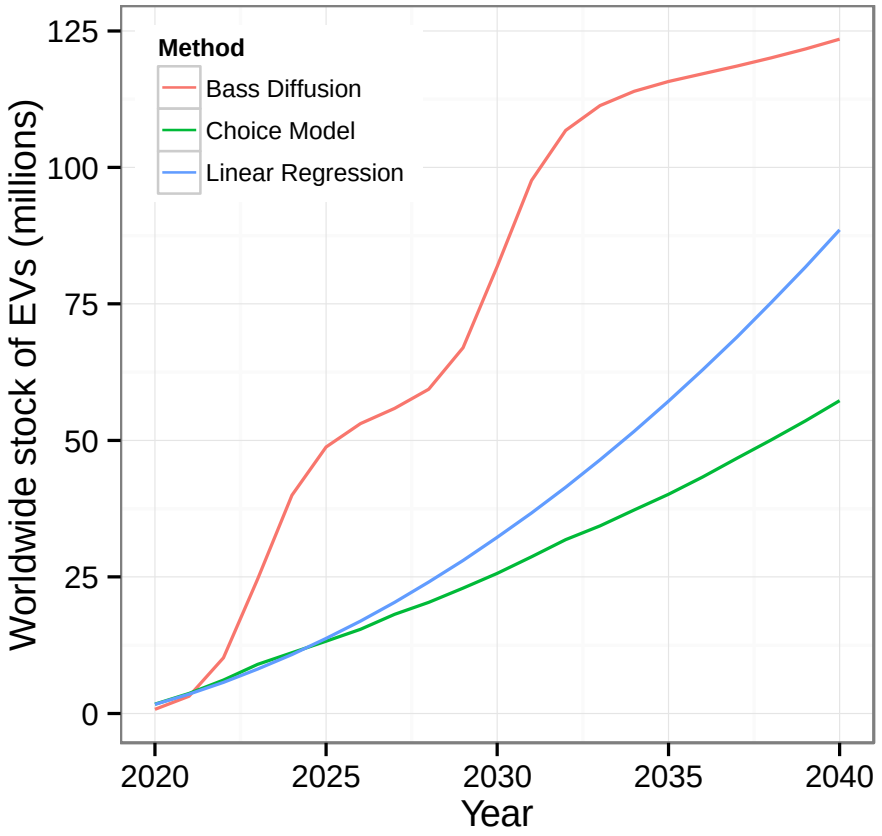


Sample of vehicle scenario projections using Bass diffusion modeling approach



How do the different model projections compare?

- Discrete choice model yields the lowest adoption, this is sensible as the models reflect current consumer preferences
- Shape of diffusion curve due to addition of demand due to exceeding vehicle lifetime
- Different models vary in estimation across the same inputs by an order of 2 (from 60 million vehicles in 2040 up to 120 million vehicles)



Discussion

- Despite consistency in model inputs, there are significant differences in outputs. The choice of model matters!
- 100 million vehicles by 2040 is an optimistic projection for choice and regression models but is achieved in the diffusion model.
- International factors are vital to consider and lead to stark differences in adoption potential across all three models.

Ongoing work

- Further calibration of models is needed:
  - Data cleaning
  - Investigating combinations of different variables
- Incorporating more variables and scenarios (e.g. charging infrastructure)
- Focusing on policy impacts and integrating existing policies
- Investigate uncertainty in each modeling scenario