# Technological Progress and Alternatives to Fossil Fuels in the Transportation Sector
# … According to a Policy Wonk, Regulator, and Academic


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# My Tasks

1. Assigned task
   - Assessment of alternatives to fossil fuels and ICE vehicle technologies for short and long term—to give update on market and technology trajectories and related policies
2. Self-appointed task
   - How to increase the impact and value of applied economic research—in terms of informing policy… bringing science to policy

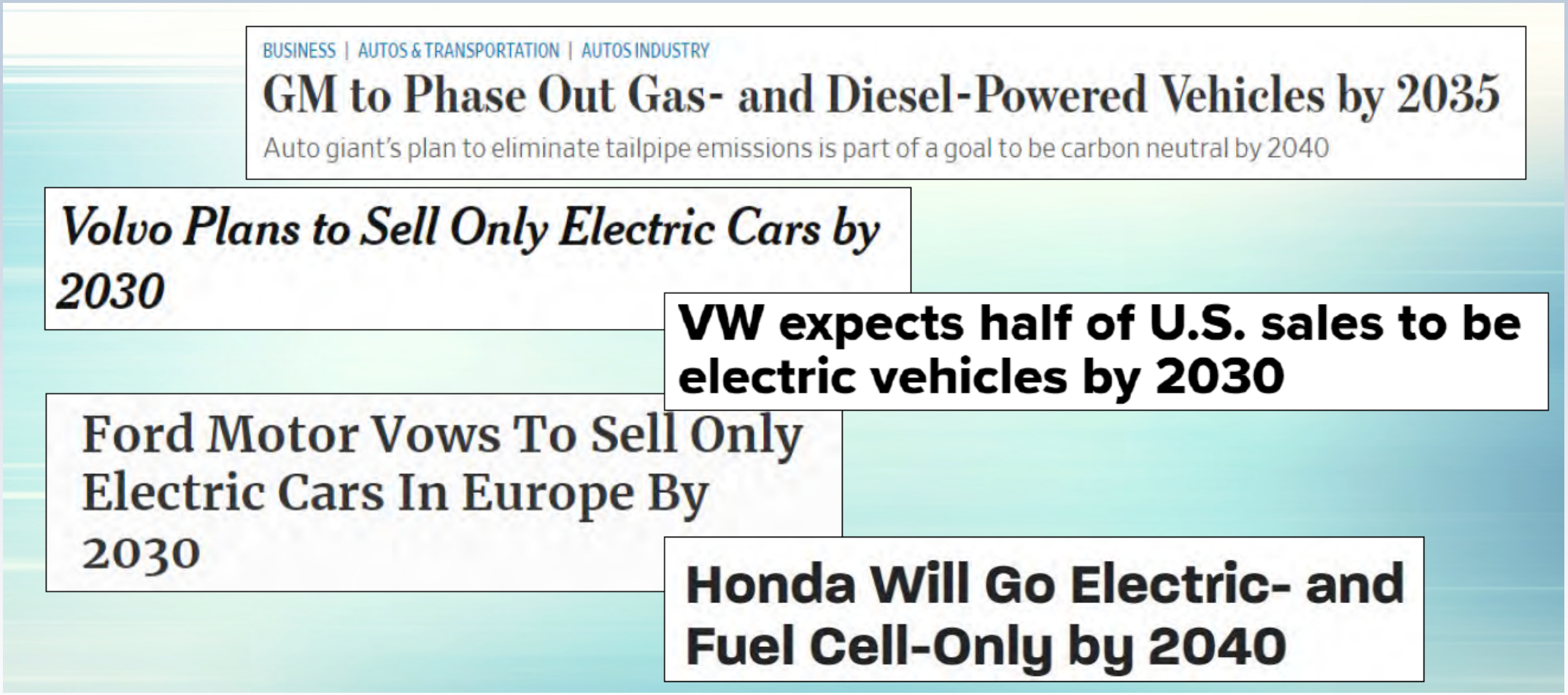
# Further Self-Introduction… and Disclaimer☺

- Unconventional path through academia.
- Knowledgeable about many disciplines and methods but master of few
  - amateur economist
- Recent expertise: merging research and policy (CARB)
- Key to success: Cross-disciplinary and diligent at learning how everything connects: how the world changes—connecting the dots.
  - Good at external validation, avoiding reductionism, understanding path dependence and innovation processes

# Task #1: Assess Market, Technology, and Policy Trajectories

## (economics, political science, behavioral sciences, ecology, engineering)

- **Vehicles**: almost all cars, trucks, buses will eventually be electric drive
  - **Evidence**: a) automaker investments; b) total cost of ownership (TCO); c) battery cost forecasts; d) solutions to range anxiety
- **Fuels**: Electricity will eventually dominate for almost all vehicles. Plus some hydrogen
  - **Evidence**: TCO analyses and falling costs
  - **Issue**: what happens to oil and gas companies?
- **Vehicle (and Fuel) Use**
  - Little change likely (transit use <2%)
  - VMT reduction desirable for many reasons (but not EJ), but not so much GHG reduction
  - Microtransit and “pooling” are attractive but many barriers
    - PPPs?
    - AVs are key


BUSINESS | AUTOS & TRANSPORTATION | AUTOS INDUSTRY
GM to Phase Out Gas- and Diesel-Powered Vehicles by 2035
Auto giant's plan to eliminate tailpipe emissions is part of a goal to be carbon neutral by 2040
Volvo Plans to Sell Only Electric Cars by 2030
VW expects half of U.S. sales to be electric vehicles by 2030
Ford Motor Vows To Sell Only Electric Cars In Europe By 2030
Honda Will Go Electric- and Fuel Cell-Only by 2040

# Existing and Likely Near-Term Policy

- EU:  100% ZEV cars in 2035 (55% reduction in 2030);
- CA 100% ZEV cars in 2035 and 100% ZEV trucks in 2040 (long haul in 2042);
- 177 states (30-40% of mkt) following CA
- China ~10% now (18% in August)
- Japan lagging

# Unknowns (for now)

- **Vehicles:**
  - Timing of transition
  - Effectiveness of entrenched interests in slowing process;
  - Uncertain consumer acceptance for last 30% or so—multifamily
- **Fuels:**
  - H2 likely to play small role (renewable H2/electrolyzers follow same trajectory as batteries?)
  - Biofuels likely to play dominant role in aviation but uncertain
  - e-fuels possible for aviation… but expensive
- **Vehicle Use (VMT)**
  - Major changes only with automated vehicles (could greatly increase or modestly reduce VMT)

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# Length and Size of Transition Tail

- Political resistance to ZEVs?
  - Ideology, politicization, entrenched interests (including labor), path dependence….)
- Developing countries?
- Grid challenges?
- H2 infrastructure and renewable H2 production
- Charging business models
- Consumer and fleet demand
  - Incentives (feebates?), AVs
- Role of (slow-moving) “regulated” utilities
  - V2G
- Role of equity (social, environmental, transportation justice)

# Task #2: How to Increase Impact of Applied Economics Research

- **Overarching context:**
  - Traditional empirical research methods are less effective in periods of rapid change.

# Minimal "Systems" Innovation for 5+ Decades

## Previous Transport "Revolutions"

**Movement of People**

1. Streetcars (~1890)
2. Automobiles (Oil) (~1910)
3. Airplanes (~1930)
4. Limited access highways (~1930s…1950s)

**Movement of Goods**

1. Canals (~1800)
2. Railroads (~1830)
3. Trucks (Oil) (~1910)
4. Airplanes (~1930)
5. Containers (~1950)

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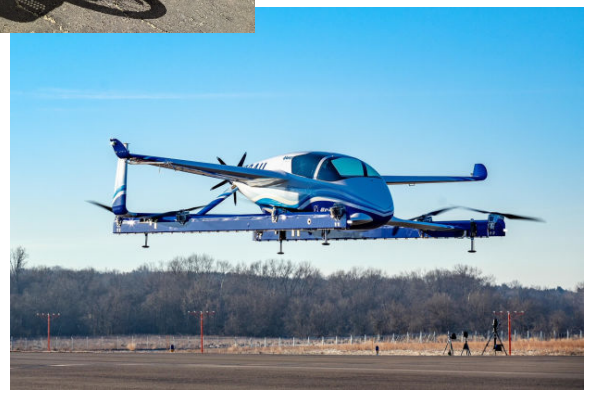
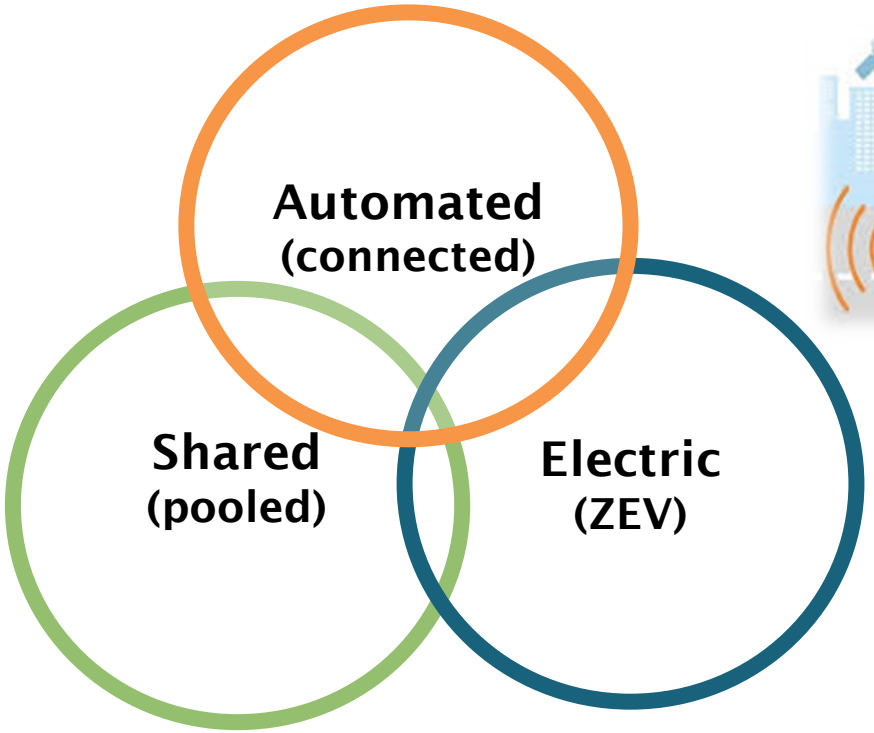
# What Is Different Now?
# Rapid Innovation and Shifting Policy Paradigms

1. New vehicle propulsion technology
2. New business models from shared economy: bikes, scooters, cars, trucks
3. Automation: personal vehicles, trucks, small delivery robots
4. Telecommunication as substitute for travel
5. Social equity (EJ, transportation justice)
6. Decarbonization policies;

How to create more economically, environmentally, and equitably transport

# Electrification + Automation + Pooling/Sharing






3 REVOLUTIONS
SHARED·AUTOMATED·ELECTRIC



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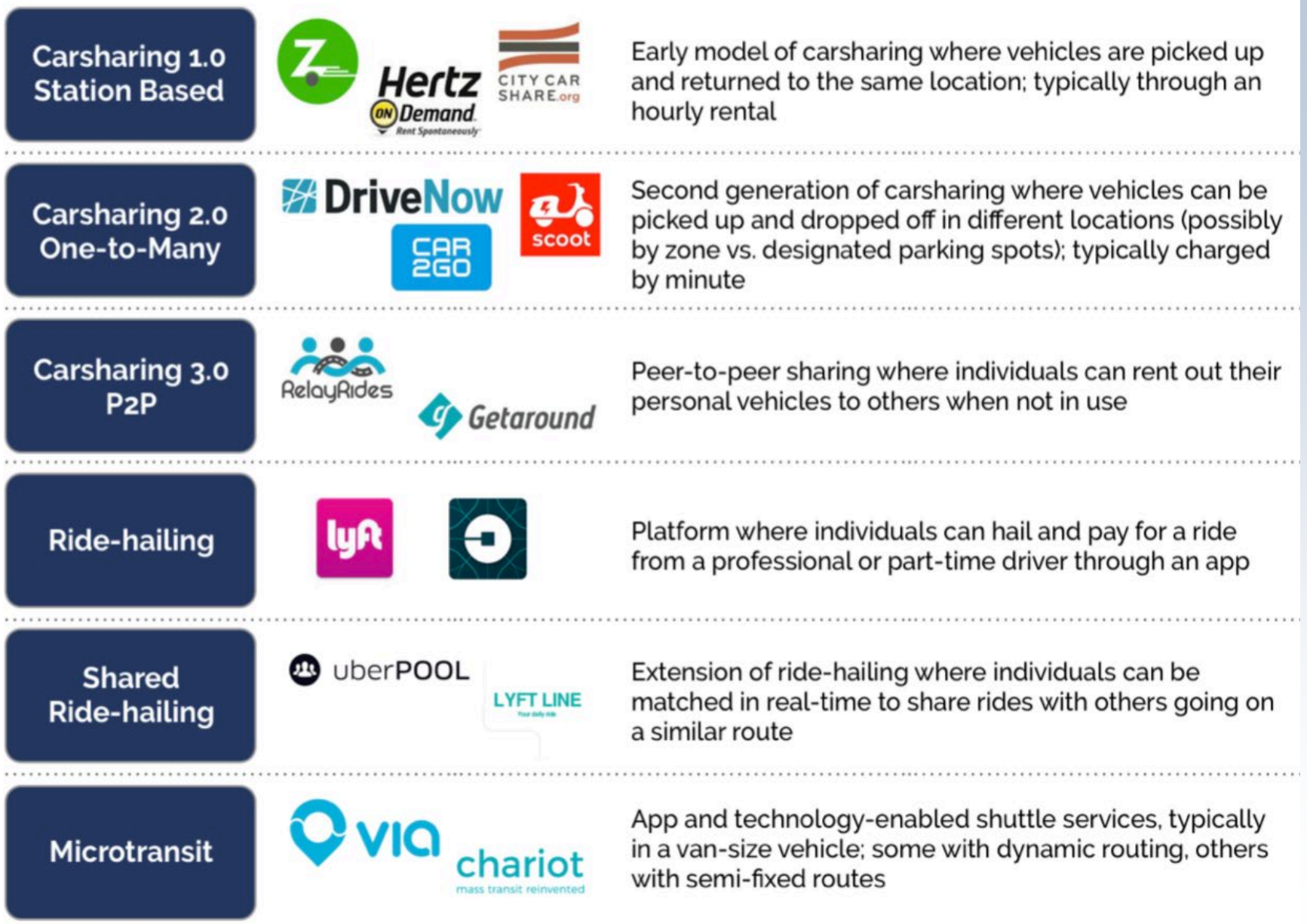
**Figure 1. The evolution of shared mobility services**




Source: Clewlow and Mishra 2017

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PHOTO: BOEING

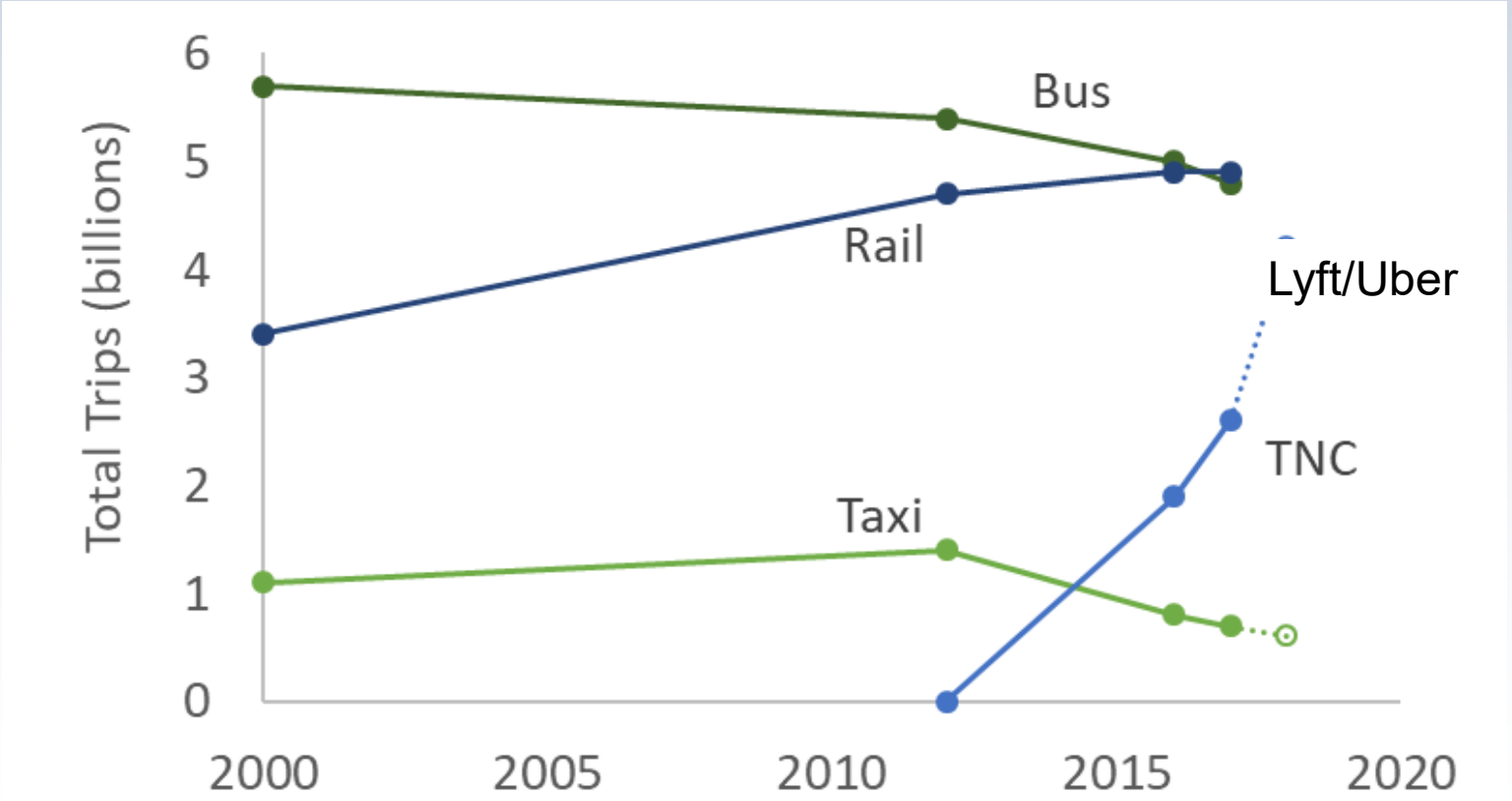
# 3 Revolutions Will Be Disruptive…In Ways Difficult to Forecast

- Taxis, transit….
- Automotive manufacturers
- Rental cars
- Insurance
- Parking
- Vehicle service and repair
- Aftermarket vehicle parts suppliers, etc.
- Oil and gas companies

## There will be disruptions

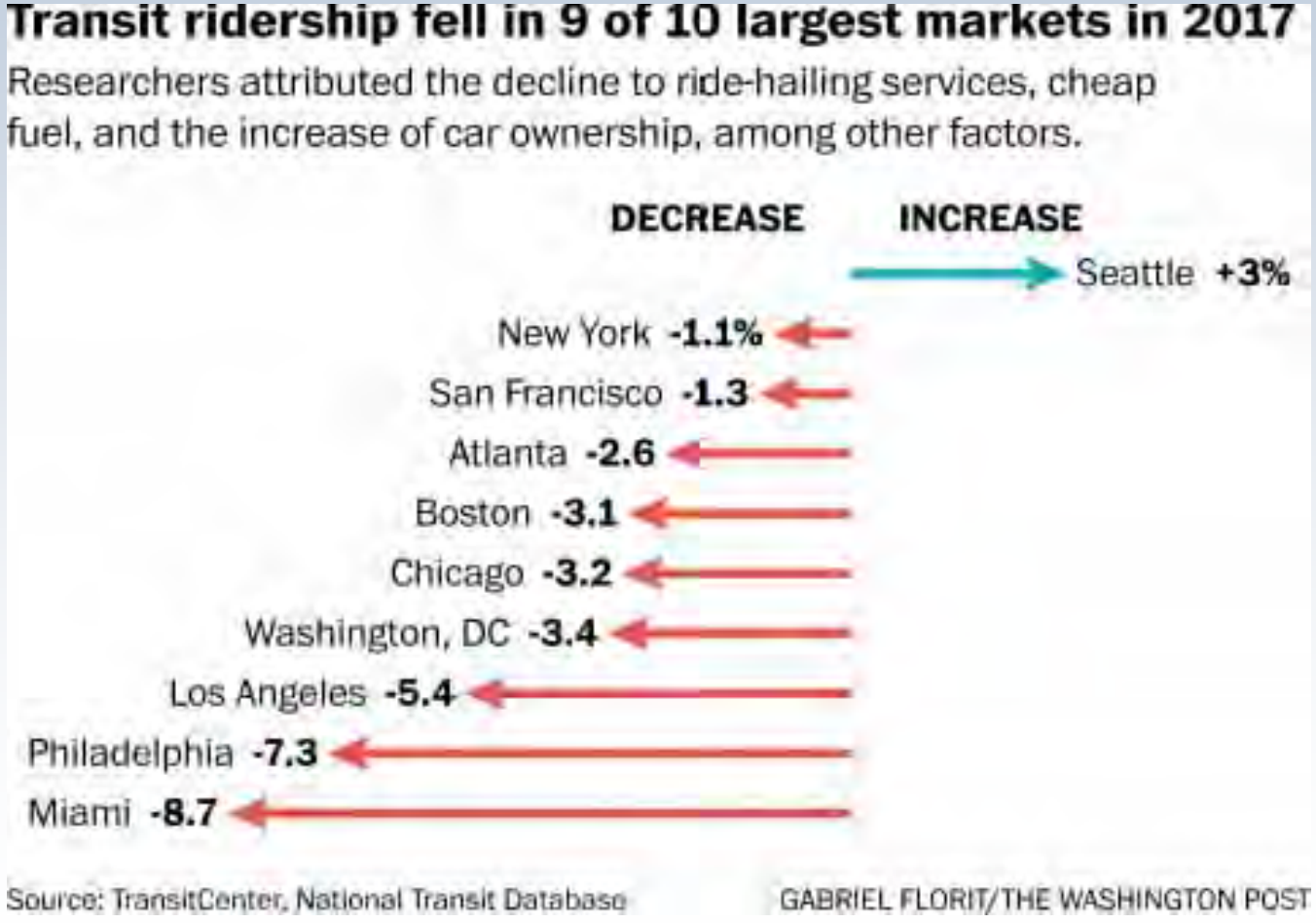
# First Disruption: Taxis

## In US, taxis lost half the market in <10 years




Transit data from APTA, Taxi data from US Census, and projections from Schaller Consulting (2018)

# Second Disruption: Mass Transit



# Bringing Science to Policy in This Rapidly Evolving World is Challenging ….requires some deviation from traditional research approaches

- How to take into account uncertainties of technology innovation; politics (EJ!); imperfect information and markets; conflicting goals (real or imagined: jobs and social justice/EJ, economic growth; geopolitical conflicts; conflicting interests of stakeholders; imperfect govt institutions for adopting, administering, and enforcing policies/regs
- One little piece: innovation. Economists have acknowledged the challenge of addressing technological innovation since Shumpeter, with Robert Solow, Ken Arrow and others addressing learning by doing, experience curves, etc
- Examples:
  - Even designing performance standards is hard (clean electricity std is being contorted in Congress)
  - RFS is hugely flawed but almost no serious consideration to replacing or updating it

# An Initial List of Market Failures/Conditions

- **Environmental and energy externalities**
- **Principal agent problem** (rental cars, truck trailers, leased vehicles, cars for legislators/execs)
- **Network externality**. Complementary products requiring large *non-recoverable* investments and investments that cannot be made by individual consumers—such as when different vehicles or different infrastructures are required (H2, bike paths for biking, smart paratransit, etc)
- **Technology lock-in**
- **Market power** (cartels, oligopolies, etc)
- **High entry barriers in auto industry**
- **R&D under-investment** due to:
  - industry diffusion (ag industry)
  - R&D spillovers. When R&D findings cannot be fully captured (leading to under-investment in R&D)
  - Learning-by-doing spillovers where mfg savings not fully captured
- **Consumer cognition** (eg, buying cars), resulting in under-investment in efficiency (related to information and loss-aversion)
- **Volatile oil prices** create uncertainty which leads to under-investment in alternatives

# What This Means for Researchers Wanting to Inform and Influence Policy

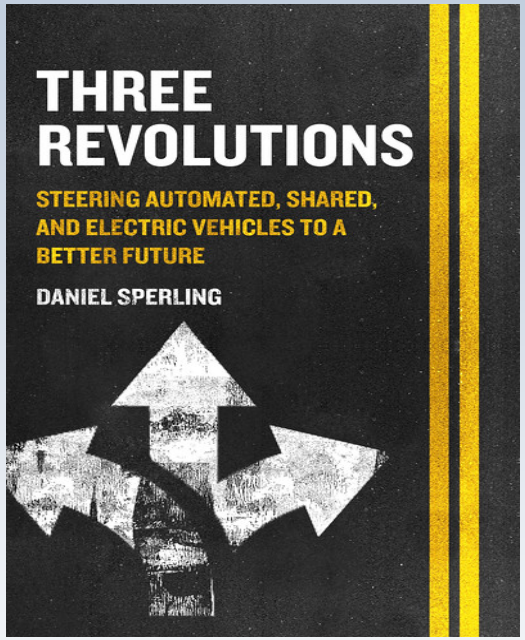
- Different framing of challenges:
  - Analyzing decarbonization **vs** assuming we are on path to decarbonization and analyzing best strategies and policies.
    - Question: is decarbonization a good idea (EVs bad idea with coal-dependent grids?) vs which policies and strategies are best to accelerate decarbonization?
  - Conceptual and analytical constructs: market economics, but also pathways (sunk costs, path dependence); incrementalism vs leapfrog (i.e., 100% renewable research by Jacobson and Delucchi); understanding innovation via learning by doing; institutional analysis (underfunded govt tends to resist change); policy implementation theory, ….

# Cautions

1. Forward looking?
   - When industry/technology is stable, then conventional empirical analysis is insightful, but with rapid transformation, need to be more forward looking
   - Robustness of datasets
   - Evolving policies affect incidence of costs and benefits
   - Interpret findings for rapidly evolving technologies, investments, behaviors
   - ➢ Suggestion: NBER and journals require “forward looking” in conclusions/recommendations
2. Beyond “gotcha”
   - Example: Critiquing one small element of a policy, downplaying policy evolution (e.g., GHG stds, LCFS…)
3. Externality validity. Connect findings (and hypotheses) to real world. Researchers often put in a sentence but don’t elaborate. Useless for policy makers
4. Implementability: Efficiency vs other criteria
   - Many new policy instruments are hybrids of market based and regulatory instruments

“We can not solve our problems with the same thinking [and institutions and research] we used when we created them.”

- Albert Einstein




# Thank You