

**Research Overview:  
Technology, Vehicle Characteristics,  
and Costs of Fuel Economy/GHG  
Standards**

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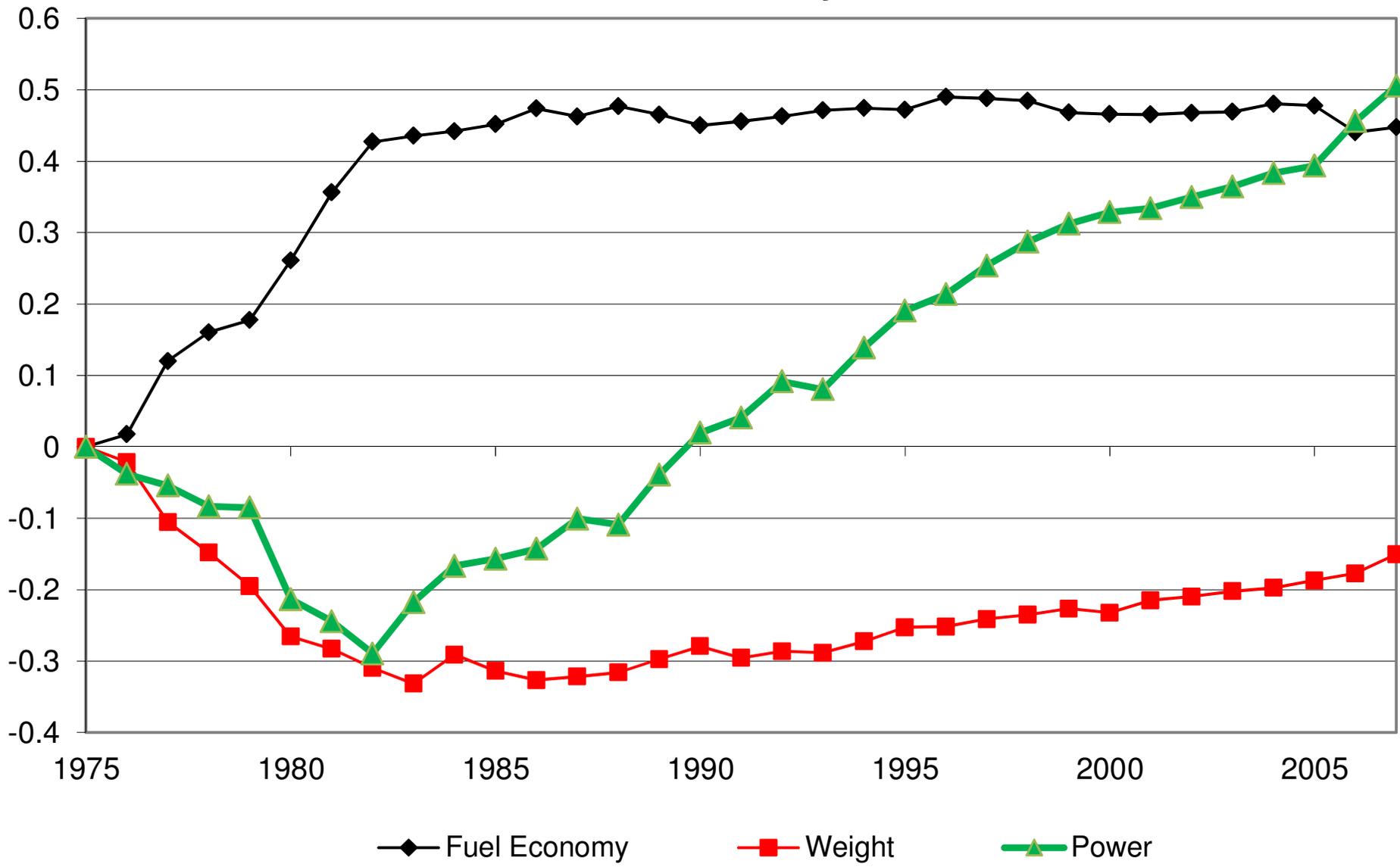
# Recent Research

- Passenger vehicle rebound effect
  - How does fuel economy (as opposed to fuel prices) affect miles traveled?
  - Using NHTS data, address endogeneity of fuel economy and multi-vehicle households
- Effects of tightening standards on vehicle characteristics (with Thomas Klier, Chicago Fed)
  - Examine recent policy developments in US and Europe
  - Focus on properly defining the baseline, against which costs and benefits of tighter standards should be measured
  - How have standards affected:
    - The rate of technology adoption?
    - Vehicle characteristics other than fuel economy?

# Why We Need to Model Dynamics?

- Typical approach (in literature, among regulatory agencies) to estimating costs and benefits of tighter standards:
  - Begin with an equilibrium prior to tighter standards (e.g., 2011, for the 2016 standards)
  - Use a computational model to estimate change in fuel economy, vehicle prices, etc., relative to initial equilibrium, such that manufacturers comply
- Figure 1 shows steady increases in horsepower and weight from 1985-2005, when standards were essentially constant
  - The figure suggests manufacturers used power train improvements to increase these characteristics, and would continue to do so in absence of tighter standards
- Therefore, the appropriate baseline, from which to measure costs and benefits, is not the equilibrium prior to the tighter standards

**Figure 1: Fraction Change in Fuel Economy, Weight and Power, 1975-2008 for Cars Sold by U.S. Manufacturers**



# Simple Model to Illustrate the Importance of Dynamics

- Manufacturer starts with a particular power train for a given vehicle, and can add technology to improve efficiency
- Efficiency fixes location of frontier, which represents combinations of fuel economy and horsepower such that marginal costs are constant
- Given the efficiency, manufacturer then chooses fuel economy and horsepower, locating along the frontier (see Figure 2)
- Frontier shifts out over time because of innovation and other factors (Figure 3)

Figure 2. Technology Frontier

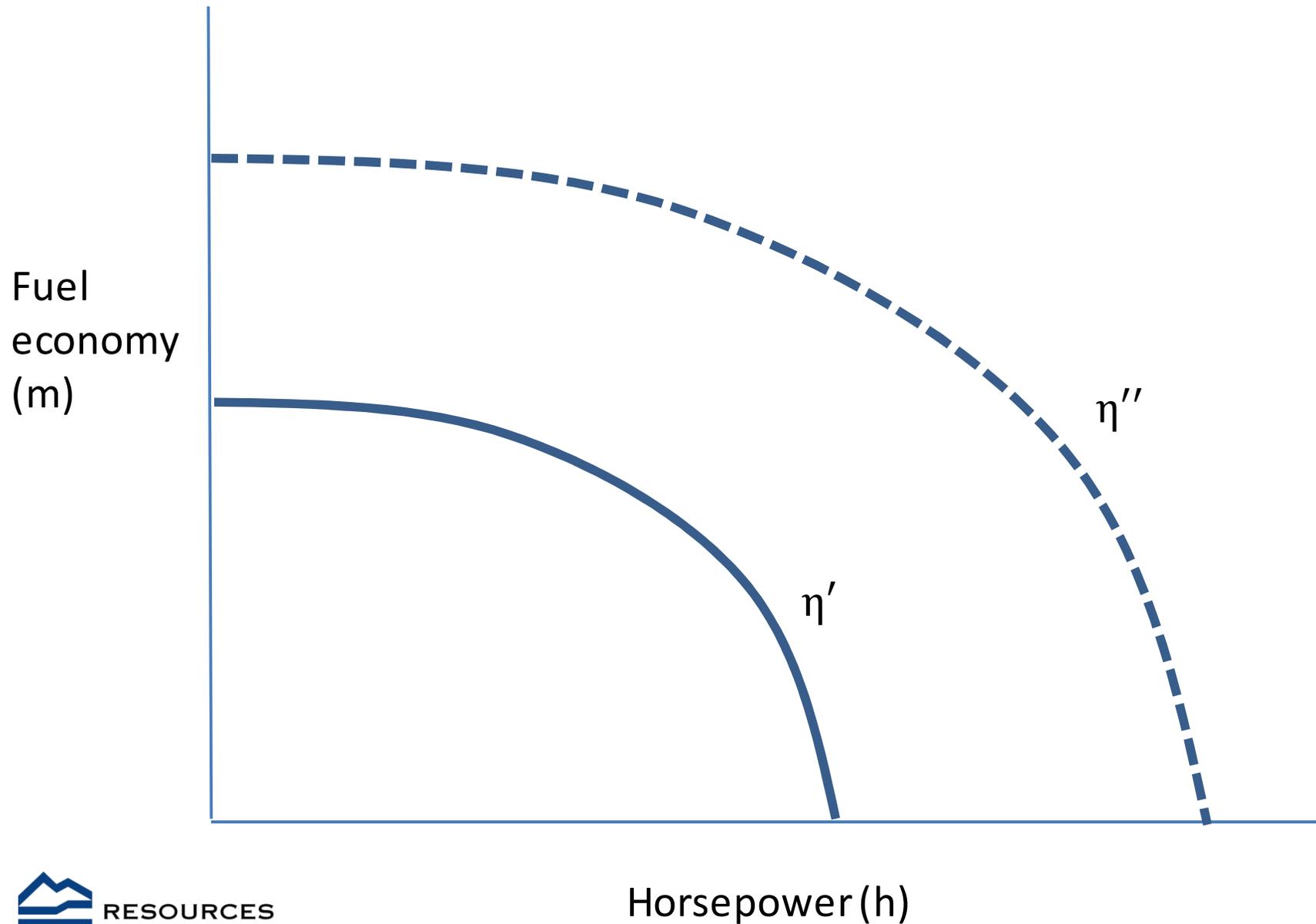


Figure 3. Equilibrium Without Tighter Standards

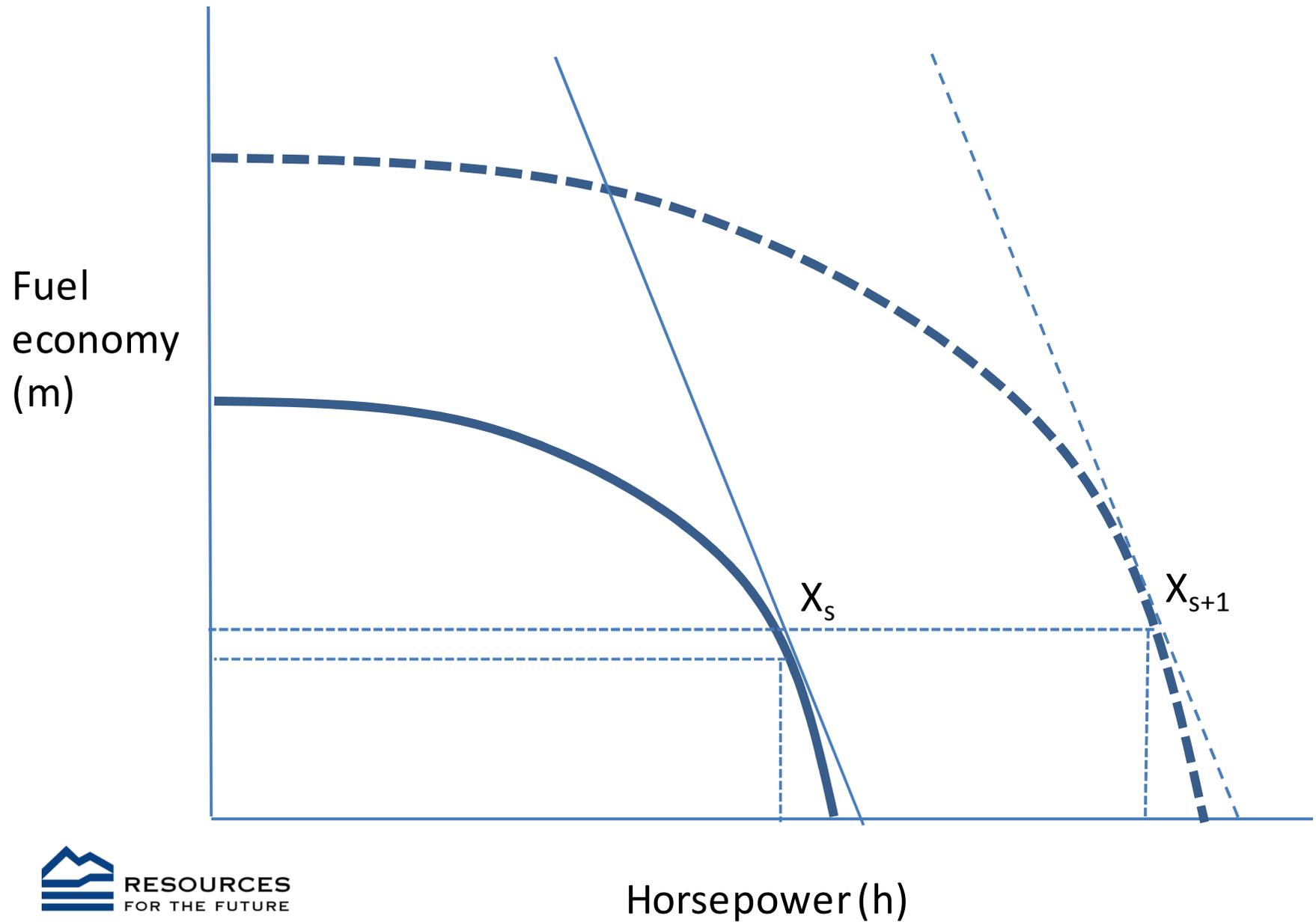
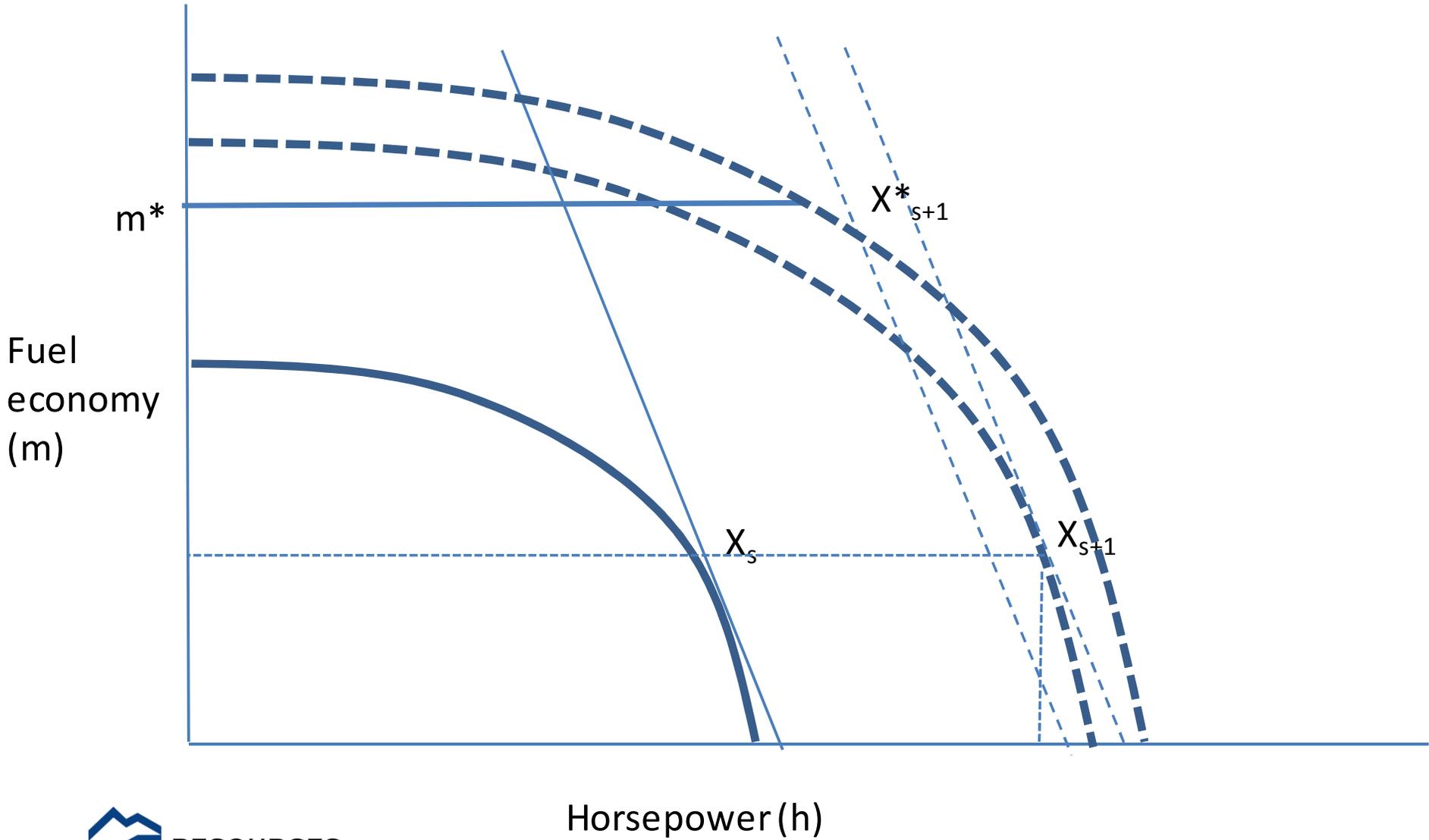


Figure 4. Equilibrium with a Tighter Fuel Economy Standard



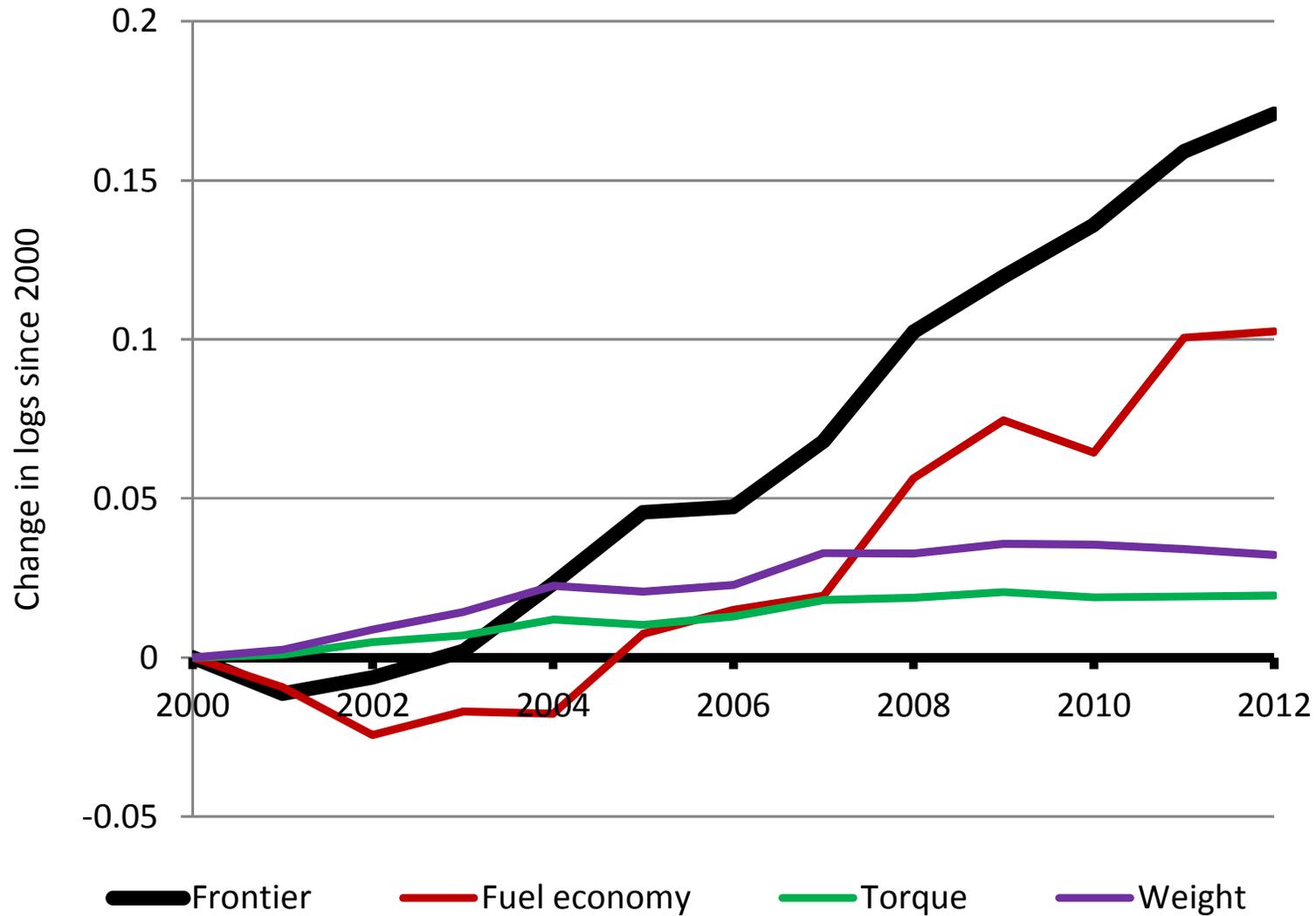
# Implications for Welfare Analysis

- Standards cause more efficiency adoption and movement along the frontier (Figure 4)
- Consumer welfare improves in absence of tighter standards, and should be baseline against which the effects of standards are measured
- Summary
  - Previous welfare analysis rule out certain manufacturer behavior/responses, such as innovation and shifting along the frontier
  - This causes welfare cost estimates to be too high
  - Ignoring technology adoption in absence of tighter standards causes welfare cost estimates to be too low
  - Which effect is bigger?

# Evidence from Recently Tightened Standards

- We look at manufacturer behavior in response to four examples of recently tightened standards
  - US light trucks (2005 and 2011); US cars (2011)
  - European cars (2007-2009)
- Evidence that the standards increased the rate of technology adoption
- Evidence the standards reduced US light truck torque (from no-policy case); weaker evidence/smaller effects for US cars and European cars
- Comparing observed equilibrium and estimated counterfactual, consumer valuation of lost torque is same order of magnitude as value of fuel savings

# Figure 5: Fuel Economy Technology Adoption for U.S. Light Trucks



# Upcoming Research

- Ex post welfare analysis of US light truck standards
  - Preceding welfare estimates were back-of-envelope calculations, lacking fully dynamic model
  - Next: estimate fixed costs of vehicle/engine redesign
  - Challenges to putting together all the pieces: demand estimation, including manufacturer behavioral margins, and cost estimation
- R&D expenditure, patenting, and product improvements
  - Standards, fuel prices, and other factors should affect innovation
  - Very little research on vehicle innovation, particularly focusing on changes in product attributes as opposed to patents
  - How do firms make investment decisions? Strategic interactions?
  - How do consumer preferences and policies affect these decisions?

## Other Questions for Discussion

- Empirical analysis of technology incentives for fuel prices, standards, fee-bates
- Consumer demand for other vehicle characteristics
- Uncertainty (regulatory stringency, consumer demand, etc.)
- Effects of crediting rules on costs and benefits of standards