

# Decarbonizing transport: Three great hopes

Christopher R. Knittel

George P. Shultz Professor of Energy Economics, Sloan School of Management, MIT

Director, Center for Energy and Environmental Policy Research, MIT

Co-Director, Electric Power Systems Low Carbon Energy Center, MIT

Co-Director, The E2e Project, MIT, UC Berkeley, U of Chicago

# Warning!

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- My crystal ball is very cloudy
- I won't predict the future
- Instead, suggest we be a little cautious in claiming a zero-carbon future is right around the corner
- Will look at three somewhat independent **claims** regarding decarbonizing transportation
  - Excuse to discuss recent work from CEEPR

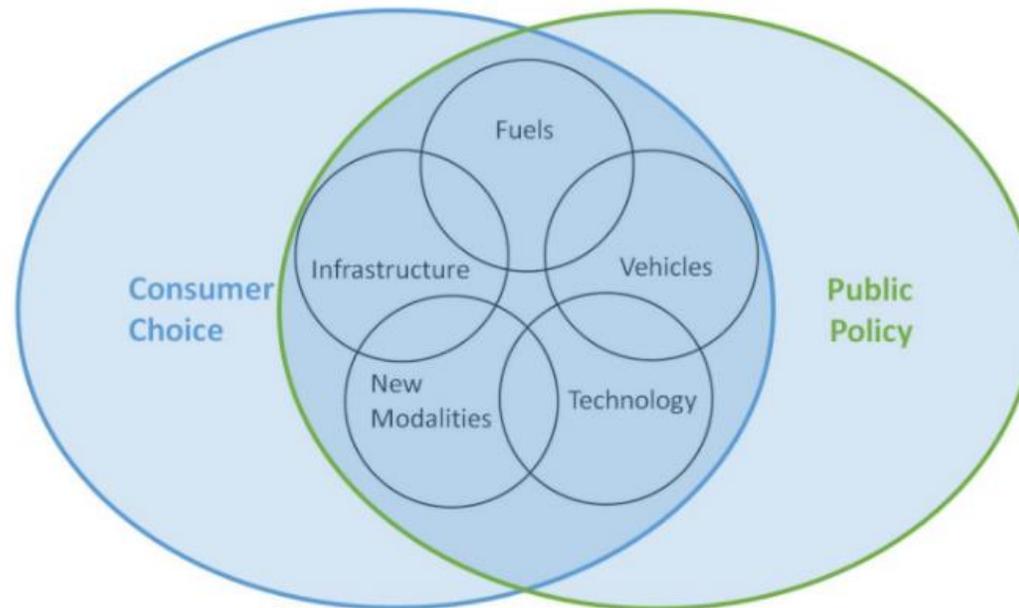
# Roadmap

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- 1. Millennials will save us
  - They won't want licenses, cars, they'll live in cities, etc.
- 2. EVs will save us
  - They are already here and just as cheap as ICE vehicles
- 3. Autonomous vehicles will save us
  - Efficiency gains from AVs will lead to huge CO2 reductions

# First, some advertisement

- MIT's **Mobility of the Future** study
  - Continuing the long line of inter-disciplinary studies
  - Out next year



# Are Millennials Actually Different? Vehicle Ownership & Usage Trends Among Generations\*

Christopher Knittel and Elizabeth Murphy  
Massachusetts Institute of Technology

## Abstract

Understanding future demand for personal vehicles is key to anticipating future personal mobility as well as greenhouse gas emissions. Significant speculation exists that Millennials in the United States will choose not to purchase vehicles, and instead they will rely more on public transportation and ride-sharing services. This work explores this hypothesis from a quantitative approach utilizing data from the US National Household Travel Survey and Census to determine whether the observed decrease in vehicle sales

“Millennials are just different”

# The Cheapest Generation

Why Millennials aren't buying cars or houses, and what that means for the economy



# Protests are consistent with this



Crowds gathered in New York for the People's Climate March in September of 2014. (350.org)

WEB ONLY / FEATURES » JULY 31, 2017

## Millennials Are Killing the Oil Industry

Hell yeah we are.

BY KATE ARONOFF

# Oil industry's fears are consistent with this

## How Millennials Could Bring The Oil Industry To Its Knees

By [Julianne Geiger](#) - Sep 01, 2016, 6:00 PM CDT



# Auto industry's fears are consistent with this

## Derek Price: Auto Companies Adapting To Millennials' Coolness Toward Cars

By JOHN MARK DEMPSEY • MAY 16, 2018



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Derek Price, owner of [Greenshoot Media](#) and author of the "Cargazing" newspaper column, says automobile companies are adapting to what seems to be millennials' cooler attitude toward cars. Derek says only about 60 percent of 18 year olds now have a driver's license, compared to 80 percent in the 1980s. He says car companies are adapting. The companies are making cars much more capable of connecting with smart phones. Another idea being a [car "subscription,"](#) in which drivers can subscribe to cars for brief periods of time with all



# But wait! Lot's of confounding variables

- Great recession
  - (young) Millennials came to driving age and entered labor force right around great recession
  - Reduced income levels from recession
- Delay in other life choices
  - Millennials are delaying marriage and children
  - More likely to live in urban settings
  - In the short run these may use patterns, but not necessarily in the long run
- Anecdotes  $\neq$  Data

# Research questions

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- (1) How different are millennials from past generations after controlling for confounding variables?
  - E.g., macro economy, income, marriage, etc.
- (2) How different are millennials from past generations when it comes to these other “endogenous” life decisions?
  - E.g., marriage, children, income (?), etc.
- (3) What does this mean for vehicle ownership and use going forward?

# Methodology

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- Econometric analysis of vehicle ownership and use controlling for confounding variables
  - Also implement NN matching
- Separate econometric analysis of how millennials differ in terms of these other life choices
- “Oaxaca decomposition” to understand what is most important

# Generations

Generation	Range of Birth Years
Generation Z	1995-?
Millennials	1980-1994
Generation X	1965-1979
Baby Boomers	1946-1964
Silent Generation	1928-1945
Greatest Generation	1901-1927

- (also do things by birth decade)

# Data

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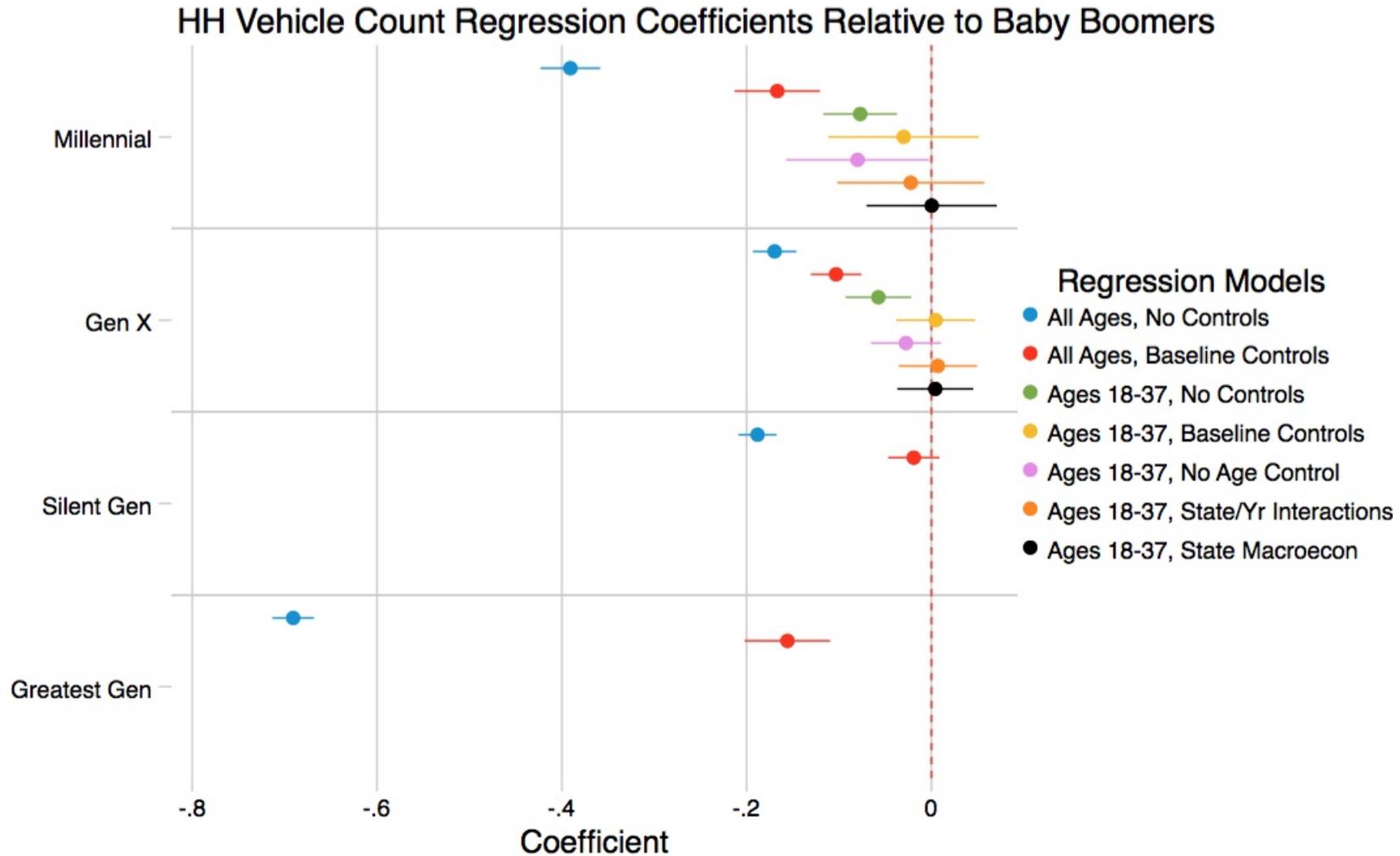
- National Household Travel Survey
  - See vehicle ownership and use (VMT) by households
  - Limited information on what types of vehicles
  - Data available for 2017, 2009, 2001, 1995, 1990, 1983
- Census and American Community Survey data
  - Annual information on household ownership and other demographics

# Basic idea

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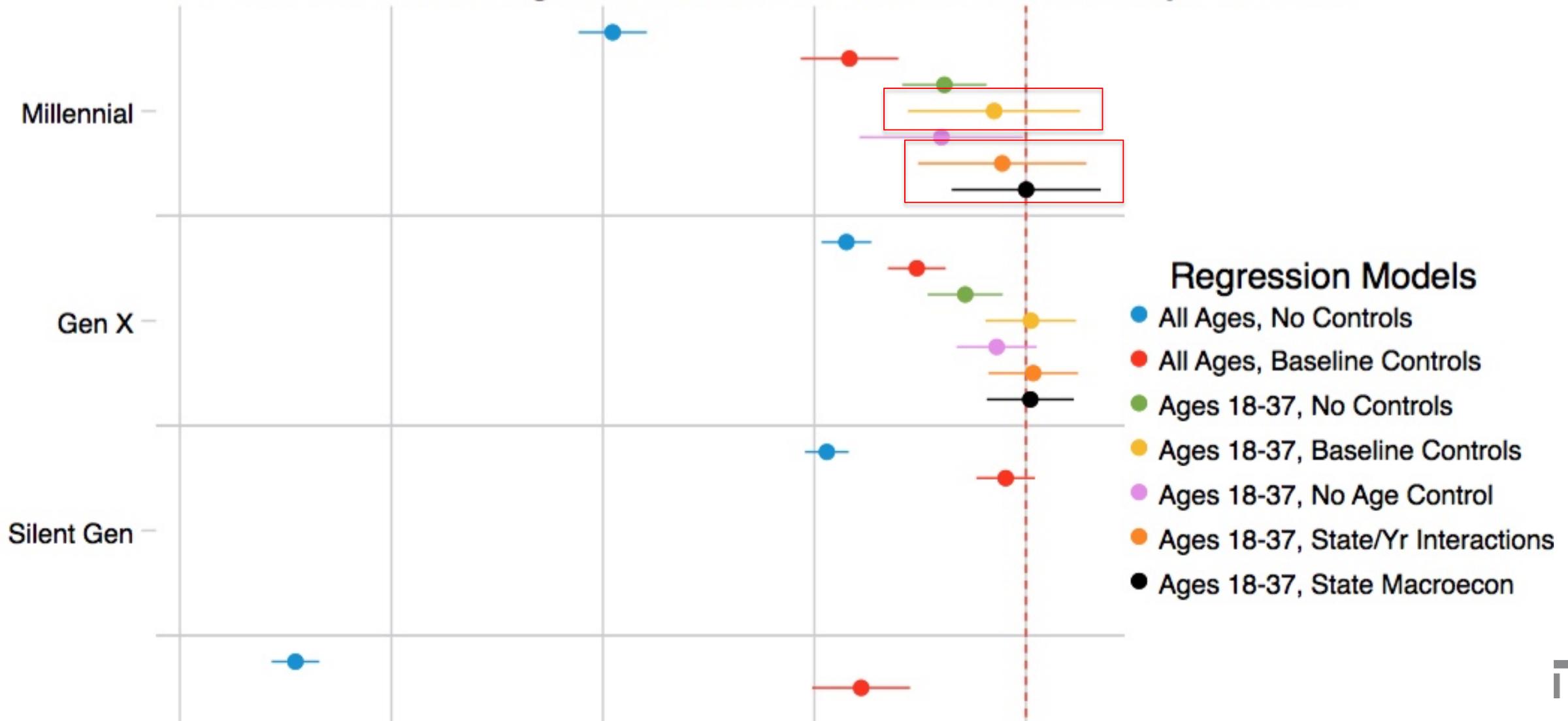
- Regress Number of Vehicles in HH and VMT controlling for above demographic variables
- Control for macro economic variables in two ways:
  - Survey “fixed effects”
  - State-level macro economics variables
- Include dummy variables for the different generations
  - Omitted group is baby boomers
- Tons of robustness checks

# NHTS Vehicle Regressions



# NHTS Vehicle Regressions

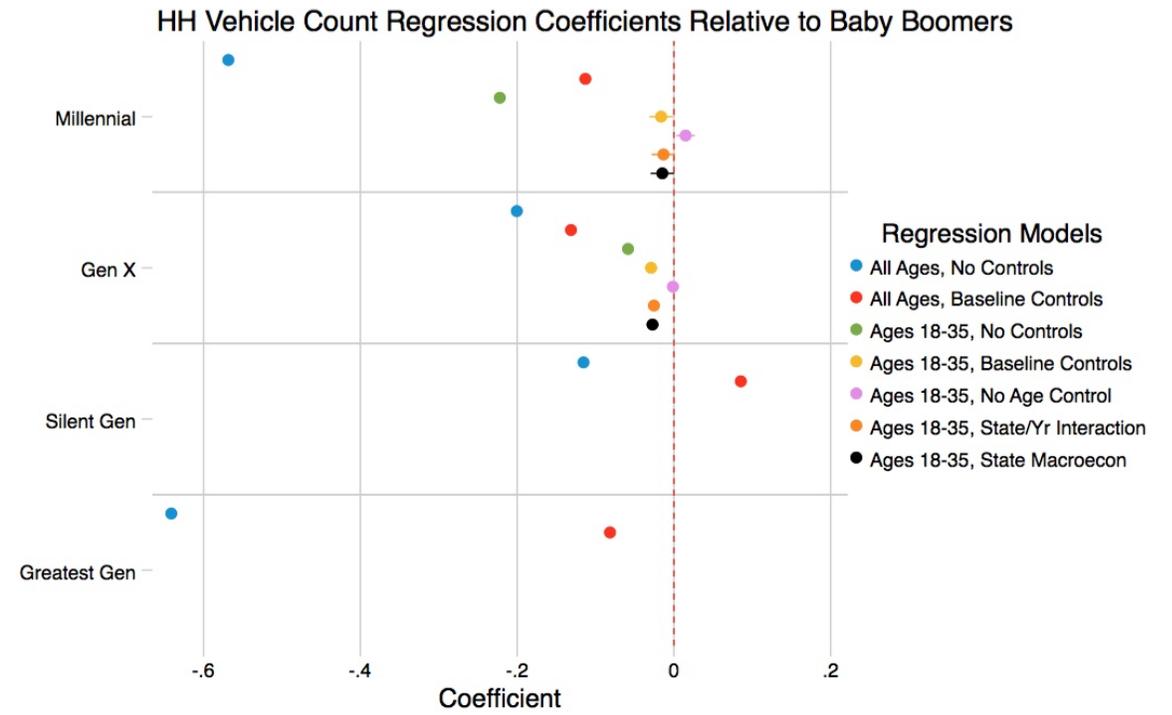
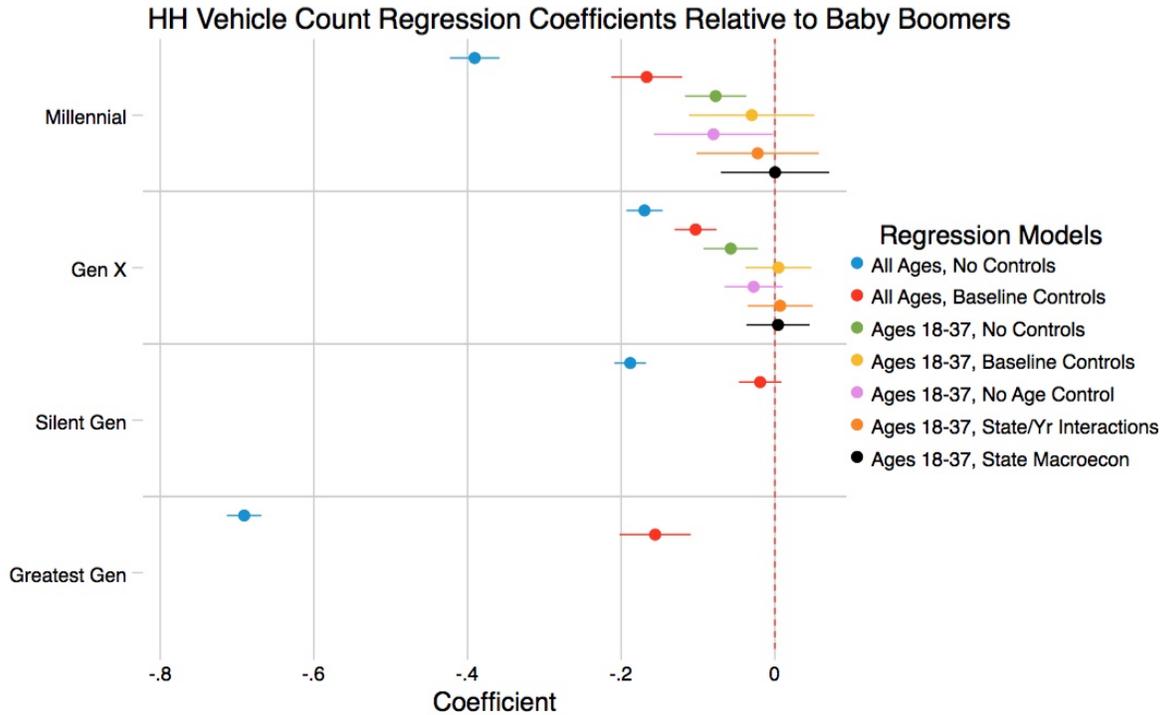
## HH Vehicle Count Regression Coefficients Relative to Baby Boomers



# Comparison: NHTS to ACS Vehicle Regression Results

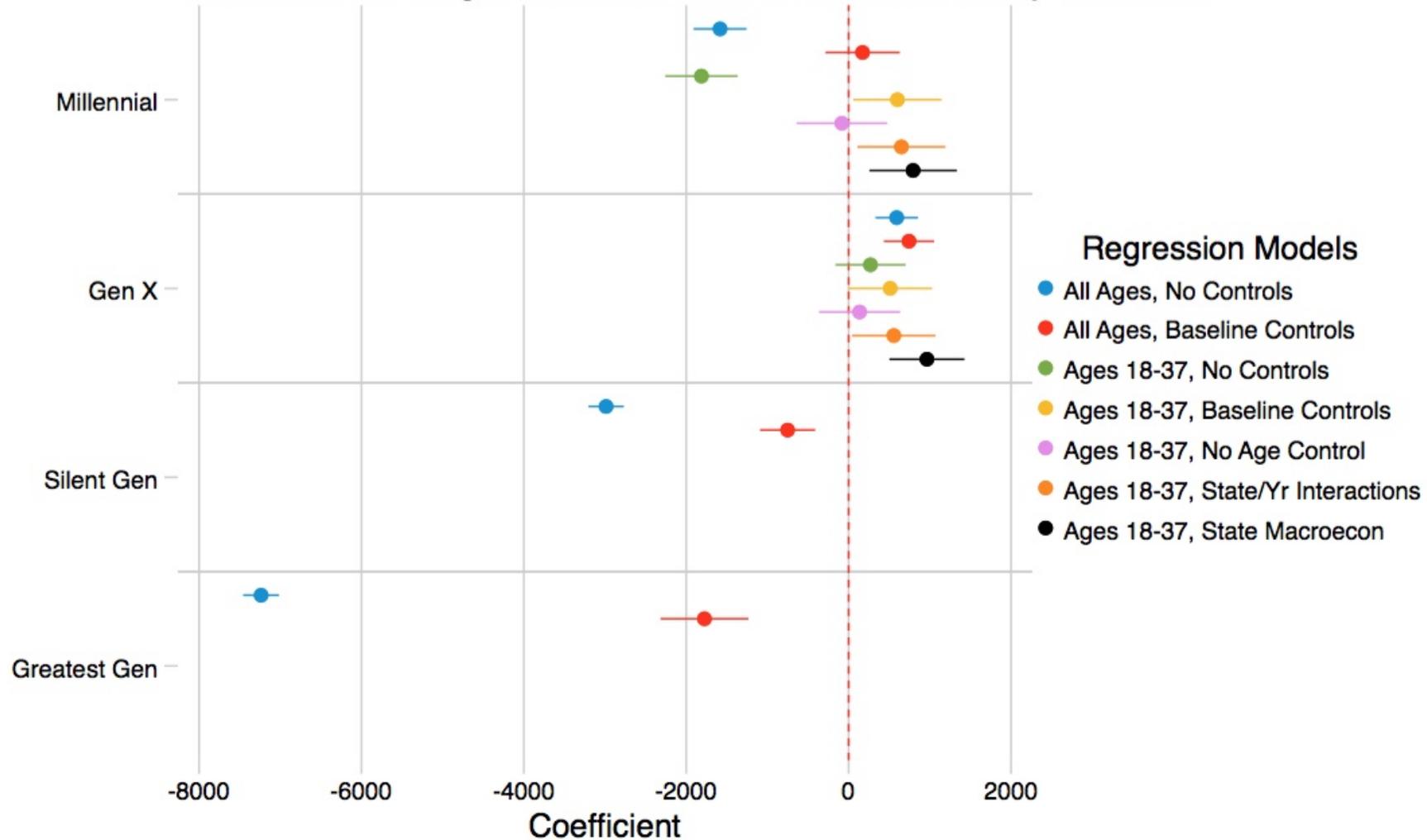
## NHTS

## ACS



# NHTS VMT Regressions

Personal VMT Regression Coefficients Relative to Baby Boomers

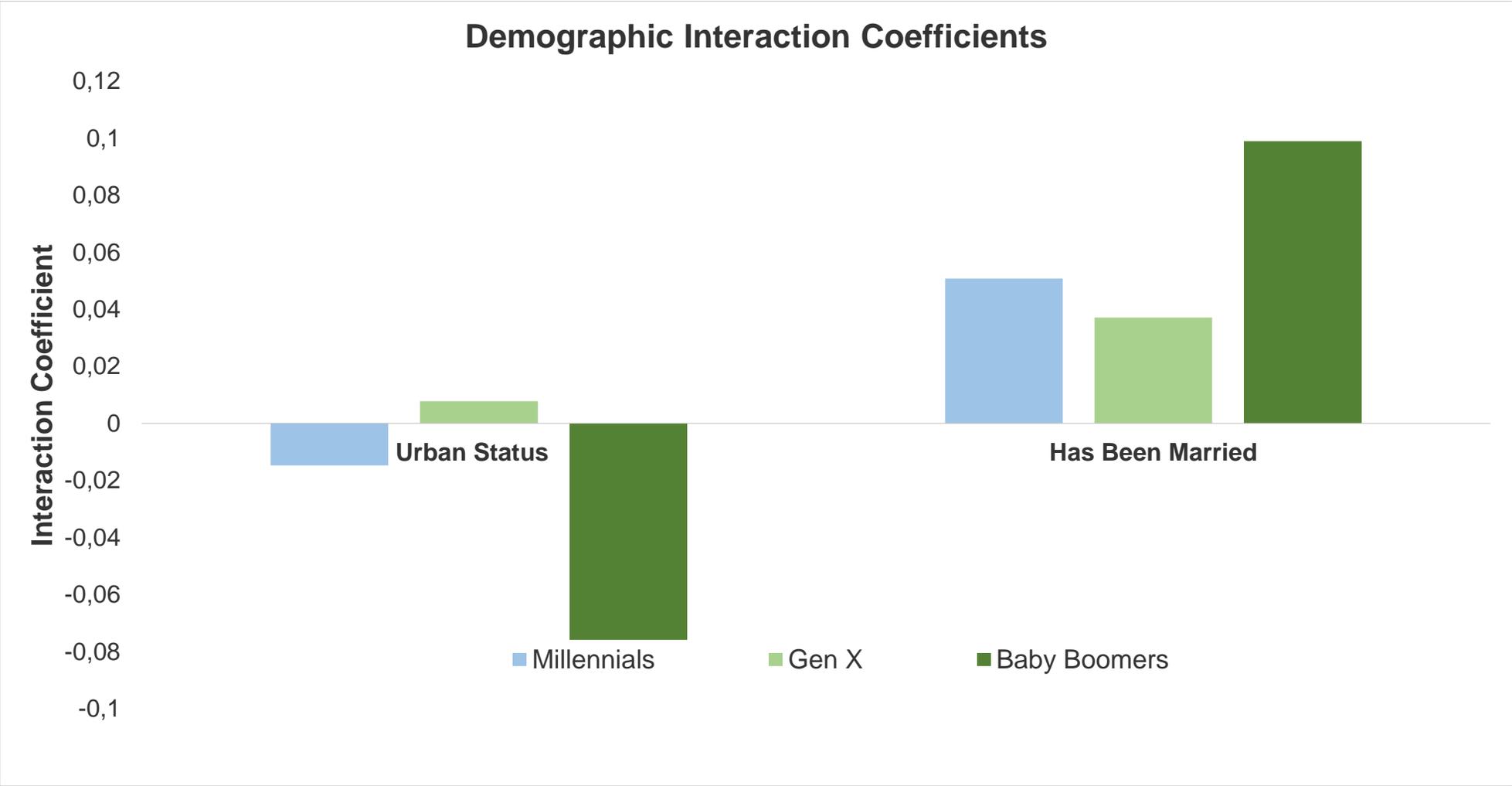


# Discussion

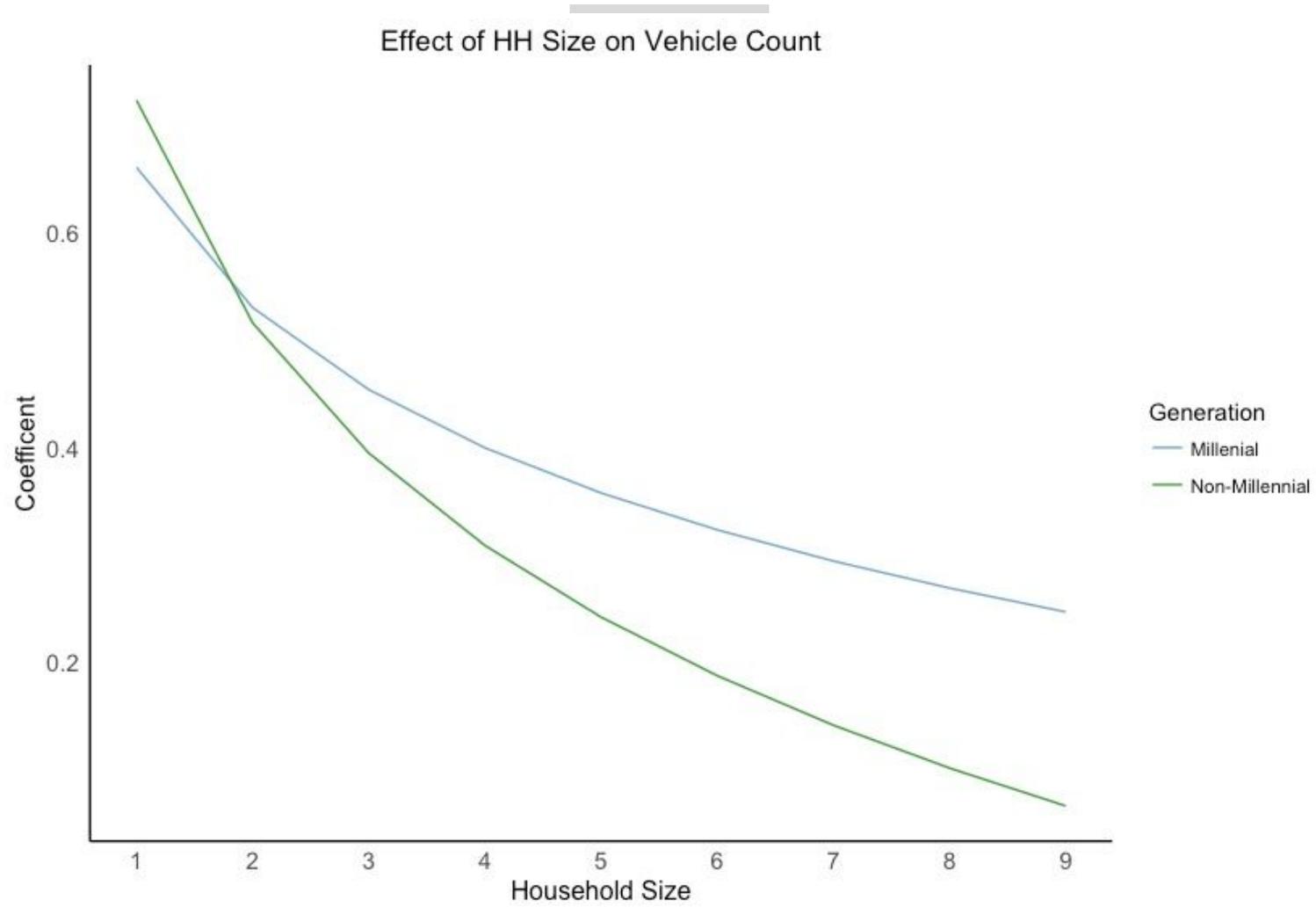
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- No evidence that Millennials own fewer cars or drive less after controlling for the above variables
- Two additional questions
  - 1. Do Millennials respond differently to changes in the controls?
    - E.g., does an extra \$10k of income change ownership more for Millennials?
  - 2. Some of the controls are life choices
    - These are “endogenous”
    - That is, Millennials might own the same number of cars *conditional* on, say, marriage, but they might also be delaying marriage

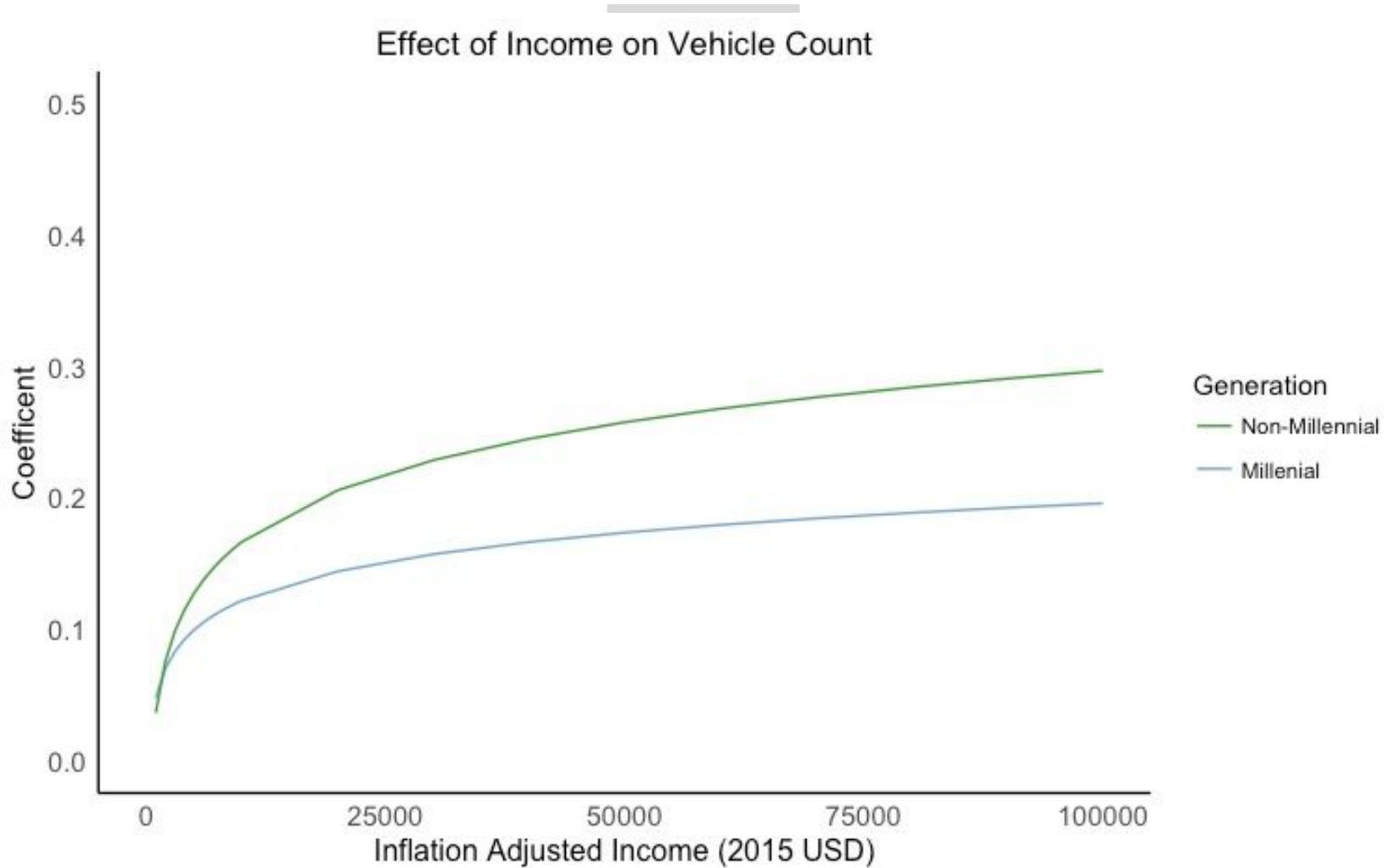
# Some evidence Millennials respond differently to life decisions



# Vehicle ownership and family size



# Vehicle ownership and income



# Discussion

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- Some evidence that Millennials respond to demographics differently
- The basic regressions we started with imply that these, on average, cancel each other out
  - But, might have a meaningful impact as we go forward
- Next question: Are Millennials changing how these demographics are “formed”

# Controlling for other factors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Urban	Urban	Previously	Previously	HH	HH	Income	Income
	Status	Status	Married	Married	Size	Size	2015 USD	2015 USD
	No Controls	Controls	No Controls	Controls	No Controls	Controls	No Controls	Controls
Millennials	-0.0164*** (-12.72)	0.0618*** (18.06)	-0.297*** (-248.08)	-0.0211*** (-5.92)	-0.561*** (-164.48)	-0.0137 (-1.32)	-11934.8*** (-97.29)	-937.6** (-2.65)
Gen X	-0.0175*** (-22.87)	0.0736*** (43.31)	-0.0973*** (-109.35)	0.00155 (0.96)	-0.184*** (-68.34)	0.00157 (0.38)	-3890.1*** (-43.22)	-233.6 (-1.84)

- Some evidence that Millennials are different in these dimensions
- These differences will interact with the previous regressions
  - Increase Urbanism => changes vehicle ownership based on the Vehicle regression

# Takeaway messages

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## Economic

- The doom-and-gloom scenario that Millennials will destroy the automotive industry is unlikely to be true
- Total vehicle sales are still likely to be reduced given the number of vehicles and individual owns in his or her life is reduced, but not permanently
- While other disruptions may change the future of personal mobility, Millennial preferences are unlikely to be the main cause

## Environmental

- Millennials are still likely to purchase and use personal vehicles, contributing significantly to GHG emissions
- The results from the personal VMT analysis indicates Millennials are driving more than prior generations, so the environmental effects from Millennials may be even larger

# Did we already know this?



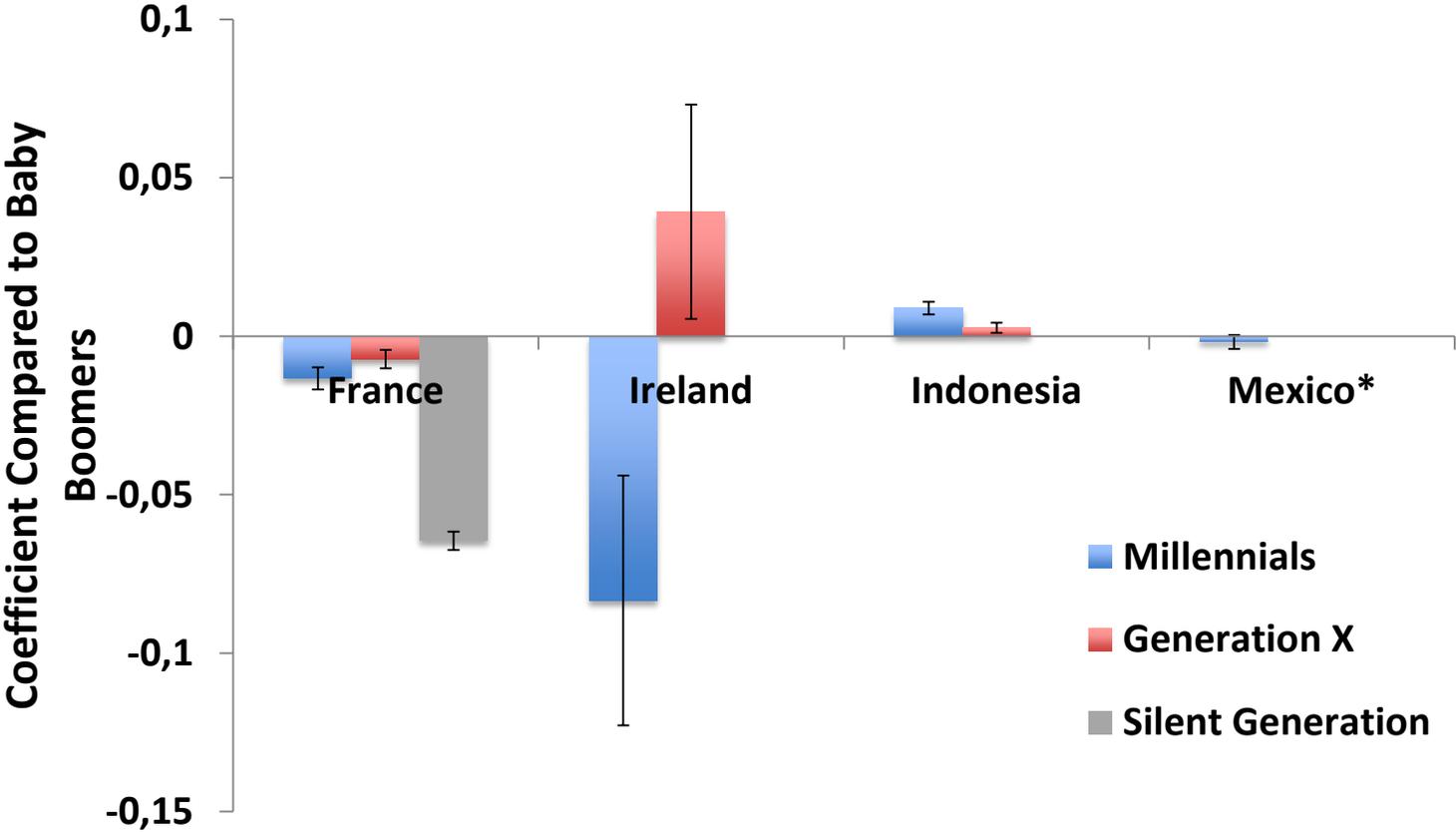
AJ Reynolds/AP

## Millennials: Not So Cheap, After All

For a while, young people were taking public transit and using car-sharing apps instead of buying cars. But now they're heading to the dealership, just like their parents.

DEREK THOMPSON | APR 21, 2015 | BUSINESS

# International comparison: Limited data



## 2. EVs are HERE!

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*Journal of Economic Perspectives—Volume 30, Number 1—Winter 2016—Pages 117–138*

### **Will We Ever Stop Using Fossil Fuels?**

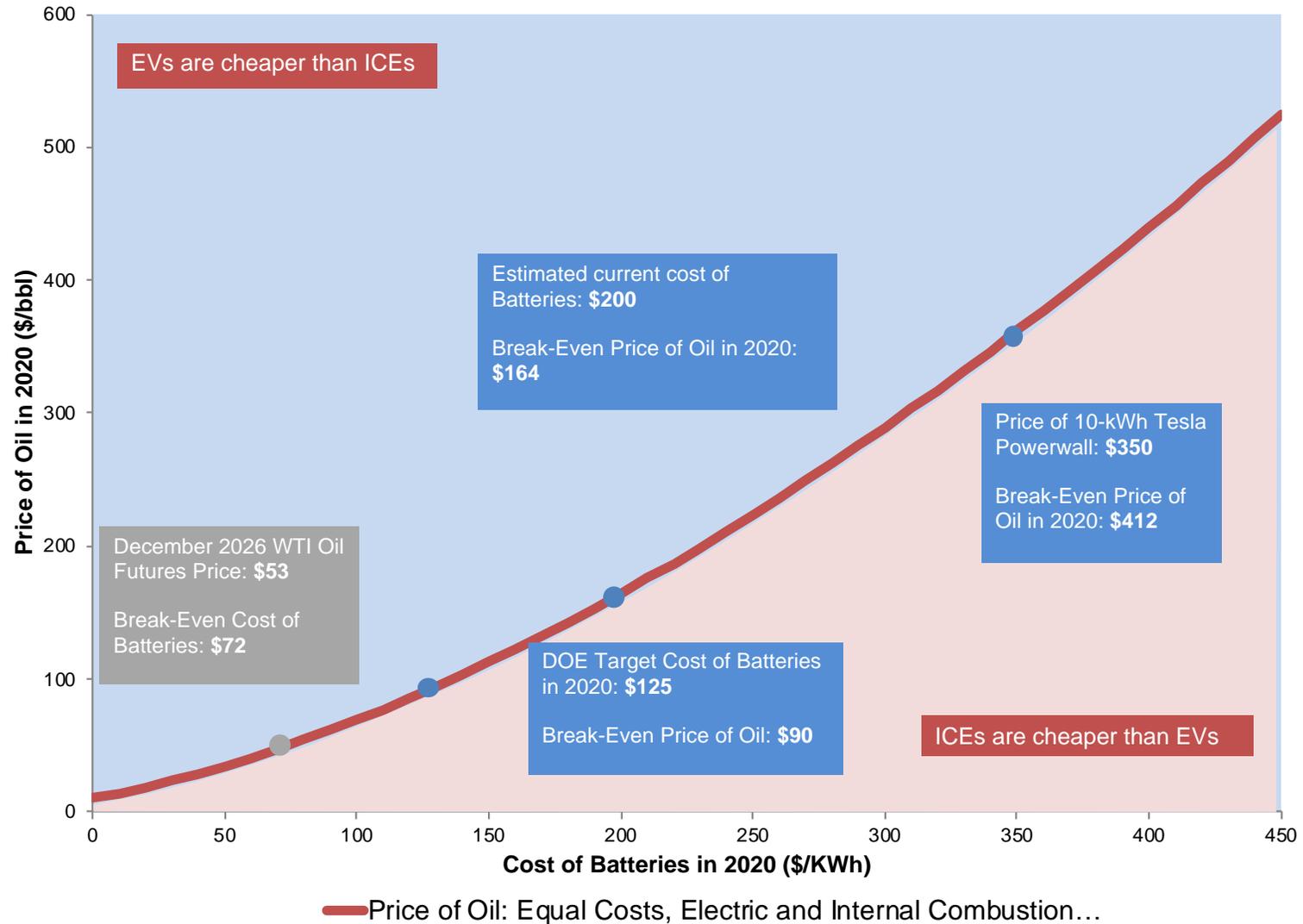
Thomas Covert, Michael Greenstone, and  
Christopher R. Knittel

# Could we run out of demand for oil?

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- We calculate, for any price of oil, what battery costs have to be for an EV to be on cost parity
- Obviously depends on a number of assumptions
  - We have a spreadsheet that you can play around with
  - Will present for:
    - Miles per year: 15,000
    - Interest rate: 0.05
    - Required kWh/mile: 0.3
    - Desired range of EV: 250 miles
    - Component **savings** for EV: \$1,000
    - Fuel Economy of ICE: 30 MPG
    - Price of Electricity: 12.2 cents/KWh

# Break-even calculations

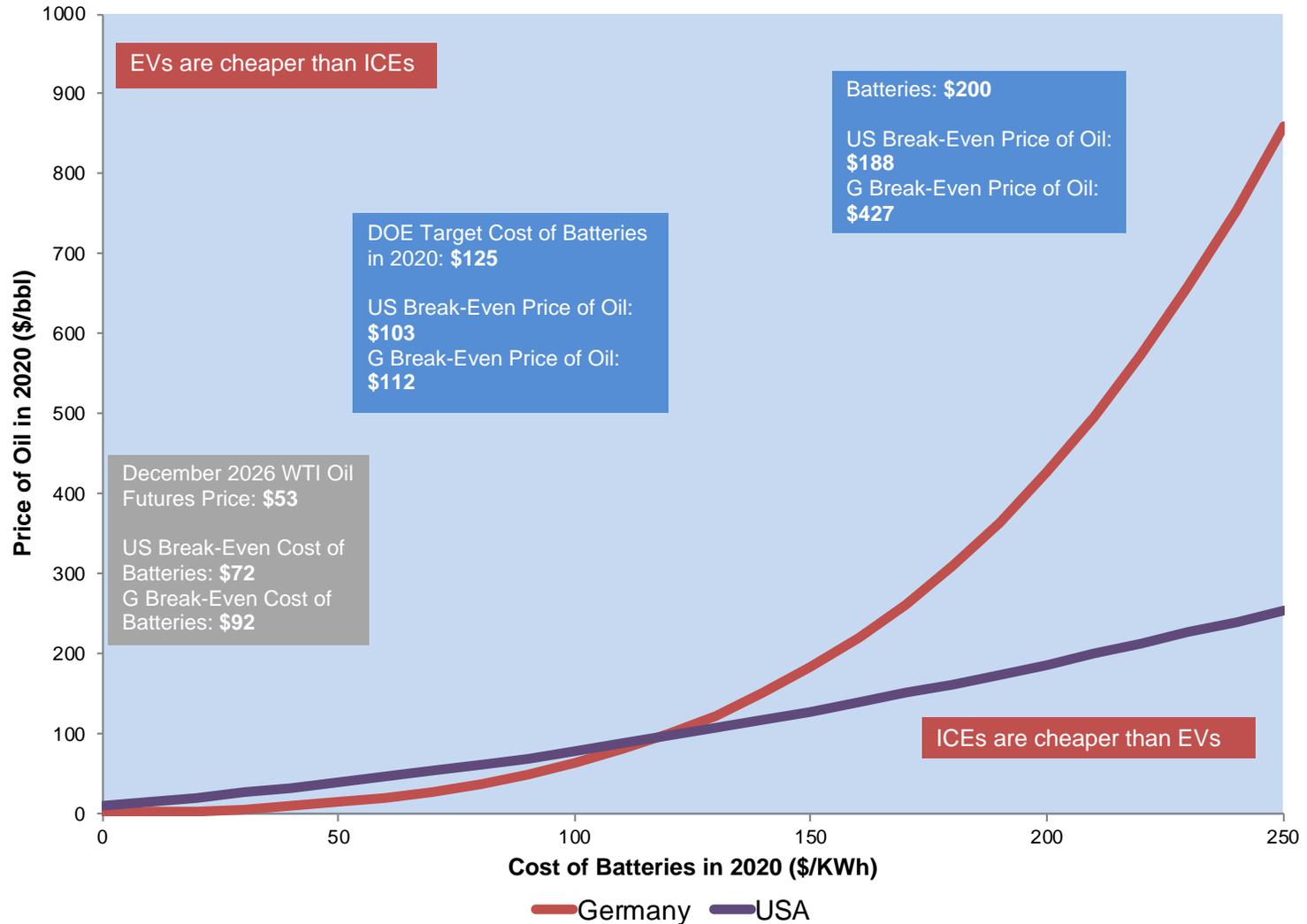


# Re-doing for Germany

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- Obviously depends on a number of assumptions
  - We have a spreadsheet that you can play around with
  - Will present for:
    - **Kilometers** per year: 13,000 (*bad for EVs*)
    - Interest rate: 0.05
    - Required kWh/mile: 0.27 (16.9 kWh/100km) (*good for EVs*)
    - Desired range of EV: 250 miles
    - Component **savings** for EV: \$1,000
    - Fuel Economy of ICE: 32 MPG/7.3 l/100km (*bad for EVs*)
    - Price of Electricity: 35 cents/kWh (*bad for EVs*)
    - **Different relationship between retail fuel prices and oil prices**

# Break-even calculations: Germany v. USA



# My cloudy crystal ball says...

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- Absent policy, we are still a ways away from EVs taking over
- Likely to continue to see more diffusion of plug in hybrids
- While less “energy” efficient because you are carrying around parts of two drive trains, likely more economically efficient (i.e. cost) because you can size your battery more efficiently
- This will imply more of a continual march up in fuel economy

# 3. Autonomous vehicles will save us!

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- Autonomous vehicles would allow for huge efficiency gains
- Through:
  - Congestion mitigation (and traffic light sensing)
  - Automated drive cycles
  - Platooning
  - "Right sizing"
  - Etc.
- But, autonomous vehicles will also decrease the marginal cost of driving
  - Explicit and implicit marginal cost

# Net effects

- The net effects of autonomous vehicles on energy consumption have huge confidence intervals



Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles



Zia Wadud <sup>a,\*</sup>, Don MacKenzie <sup>b,1</sup>, Paul Leiby <sup>c,2</sup>

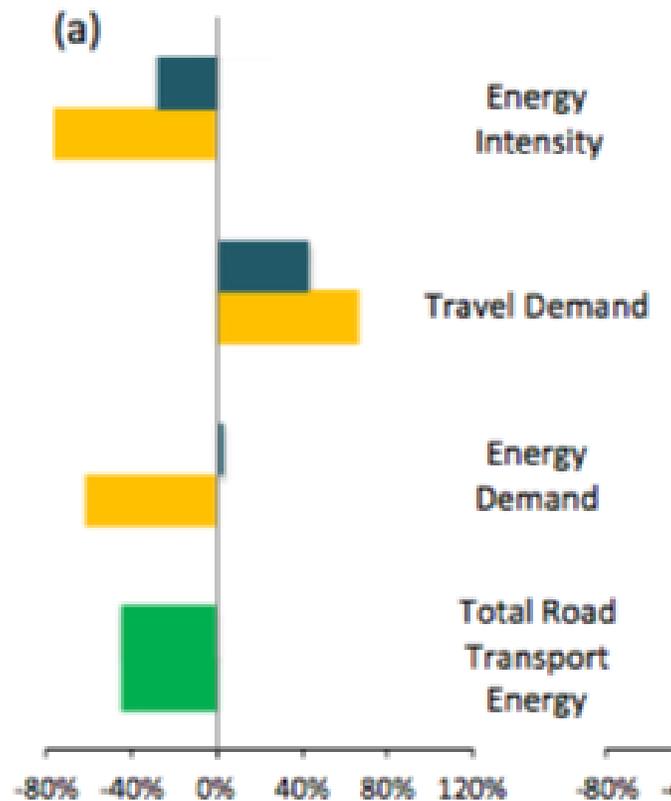
<sup>a</sup> Centre for Integrated Energy Research, Institute for Transport Studies and School of Chemical and Process Engineering, University of Leeds, Leeds LS2 9JT, UK

<sup>b</sup> Department of Civil & Environmental Engineering, University of Washington, P.O. Box 352700, Seattle, WA 98195-2700, United States

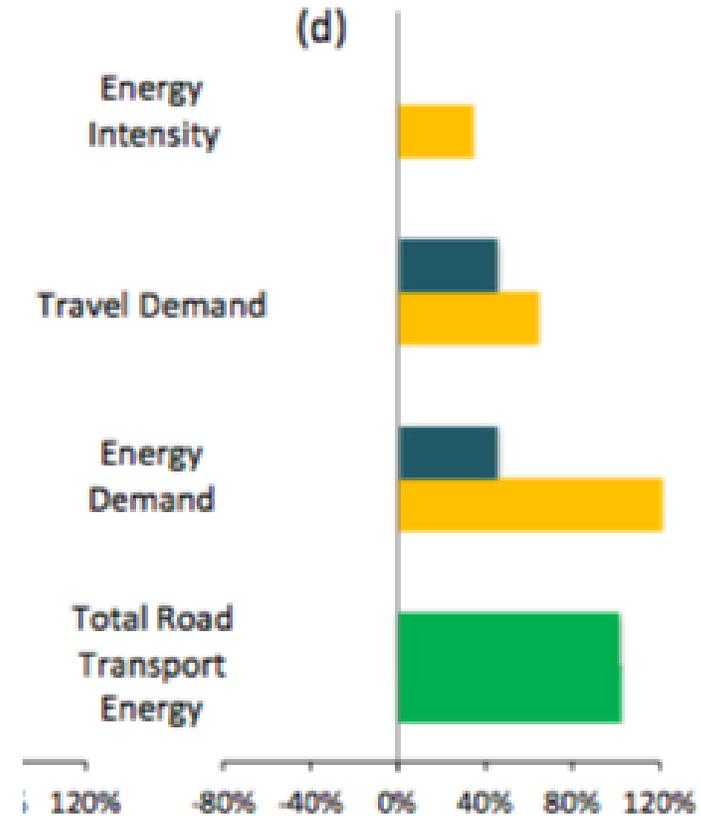
<sup>c</sup> Oak Ridge National Laboratory, P.O. Box 2008, MS 6036, Oak Ridge, TN 37831, United States

# Wide range of potential outcomes

- Optimistic scenario



- Pessimistic scenario



# Are AVs “good” or “bad”?

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- We need a lot more research on this topic
- I’d lean toward the pessimistic scenario
  - Think of the places you’d go if you could work while driving
  - Think of the times you’d send a car to get your kids
- But, energy  $\neq$  welfare
  - Those extra miles increase social welfare
- But, energy  $\neq$  CO<sub>2</sub>
  - If these are CO<sub>2</sub>-free miles, not an issue for climate change
- The team at MIT seems to be converging on a “autonomous co-pilot” view
  - We’re likely to spend decades with enhanced safety, etc, but not full automation

# Wrapping up

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- The transportation industry will continue to see huge technological gains in efficiency and automation
- Historically, these gains have only partially gone to fuel efficiency
  - Knittel (2011) shows that between 1980 to 2004, fuel economy would have increased by 80%, had horsepower and size stayed constant
  - Fuel economy actually increased by only 15%
- Absent aggressive policy, I expect we will see the same