The Rebound Effect in Transportation: Understanding the Important Implications for Climate Change

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This Briefing Asks Two Questions

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- **What are implications for climate change?**

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- **Higher fuel economy or cheaper fuels reduces the fuel costs of traveling per mile – leading to an increase in miles traveled. Expressed as the elasticity of vehicle use with respect to either marginal costs or fuel economy**

A Rebound Effect is Observed, but..

- “Research on the magnitude of the rebound effect in light-duty vehicle use dates to the early 1980s, and almost unanimously concludes that a statistically significant rebound effect occurs when vehicle fuel efficiency improves” (DOT, 2011)
- Short-run to long run transportation rebound has been estimated at 3-15% but as incomes rise price sensitivity falls. It is also important to include response to fuel prices (Small and van Dender, 2007)
- DOT review found that estimates have a mean of 23% with a range of 7-75%. Two thirds of the studies reviewed fell within 10-30%

Survey of Transportation Rebound Literature

Table VIII-2
Summary of Previous Rebound Effect Estimates

Category of Estimates	Number of Studies	Number of Estimates	Range		Distribution		
			Low	High	Median	Mean	Std. Dev.
All Estimates	22	66	7%	75%	22%	23%	14%
Published Estimates	17	50	7%	75%	22%	24%	14%
U.S. Time-Series Data	7	34	7%	45%	14%	18%	9%
Household Survey Data	13	23	9%	75%	31%	31%	16%
Pooled U.S. State Data	2	9	8%	58%	22%	25%	14%
Constant Rebound Effect (1)	15	37	7%	75%	20%	23%	16%
Variable Rebound Effect (1)	10	29	10%	45%	23%	23%	10%

(1) Three studies estimated both constant and variable rebound effects.

Source: DOT, 2011

Table VIII-3 Summary of NHTSA Estimates of the Long-Run Rebound Effect Using U.S. Annual Data for 1950-2006

Model	VMT Measure	Variables Included in VMT Equation	Estimation Technique	Rebound Effects:		
				1950-2006	2006	2010-2030*
Small-Van Dender single VMT equation	annual VMT per adult	fuel cost per mile, per Capita income, vehicle stock, road miles per adult, fraction of population that is adult, fraction of population living in urban areas, fraction of population living in urban areas with heavy rail, dummy variables for fuel rationing, time trend	OLS	33.0%	15.8%	8.0%
Small-Van Dender three-equation system	annual VMT per adult	fuel cost per mile, per Capita income, vehicle stock, road miles per adult, fraction of population that is adult, fraction of population living in urban areas, fraction of population living in urban areas with heavy rail, dummy variables for fuel rationing, time trend	3SLS	21.6%	5.8%	3.4%
Single-equation VMT model	annual VMT per adult	personal income, road miles per Capita, time trend	OLS	18.4%	11.7%	9.2%
Single-equation VMT model	annual VMT per vehicle	fuel cost per mile, personal income, road miles per Capita, time trend	OLS	17.6%	15.2%	15.7%
Single-equation VMT model	annual VMT per adult	fuel cost per mile, personal income, road miles per Capita, dummy variables for fuel rationing, time trend	OLS	34.0%	20.8%	13.6%
Single-equation VMT model	annual VMT per vehicle	fuel cost per mile, personal income, vehicles per road mile, % of fleet manufactured under CAFE standards, new vehicle prices	IV (for fuel cost per mile)	16.3%	9.2%	7.0%
Three-equation system for VMT, fuel efficiency, and vehicle stock	annual VMT per vehicle	fuel cost per mile, personal income, vehicles per capita, vehicles per road mile, fraction of adult population licensed to drive, new vehicle prices, % of fleet manufactured under CAFE standards	2SLS	29.5%	13.4%	15.9%
Three-equation system for VMT, fuel efficiency, and vehicle stock	annual VMT per vehicle	fuel cost per mile, personal income, vehicles per capita, vehicles per road mile, fraction of adult population licensed to drive, new vehicle prices, % of fleet manufactured under CAFE standards	3SLS	29.8%	13.7%	16.2%
Three-equation system for VMT, fuel efficiency, and vehicle stock	annual VMT per vehicle	fuel cost per mile, personal income, vehicles per capita, vehicles per road mile, fraction of adult population licensed to drive, new vehicle prices, % of fleet manufactured under CAFE standards	Vector auto-regression	19.9%	10.8%	--
Three-equation system for VMT, fuel efficiency, and vehicle stock	annual VMT per vehicle	fuel cost per mile, personal income, vehicles per capita, vehicles per road mile, fraction of adult population licensed to drive, new vehicle prices, % of fleet manufactured under CAFE standards	Vector error-correction	20.7%	11.2%	--

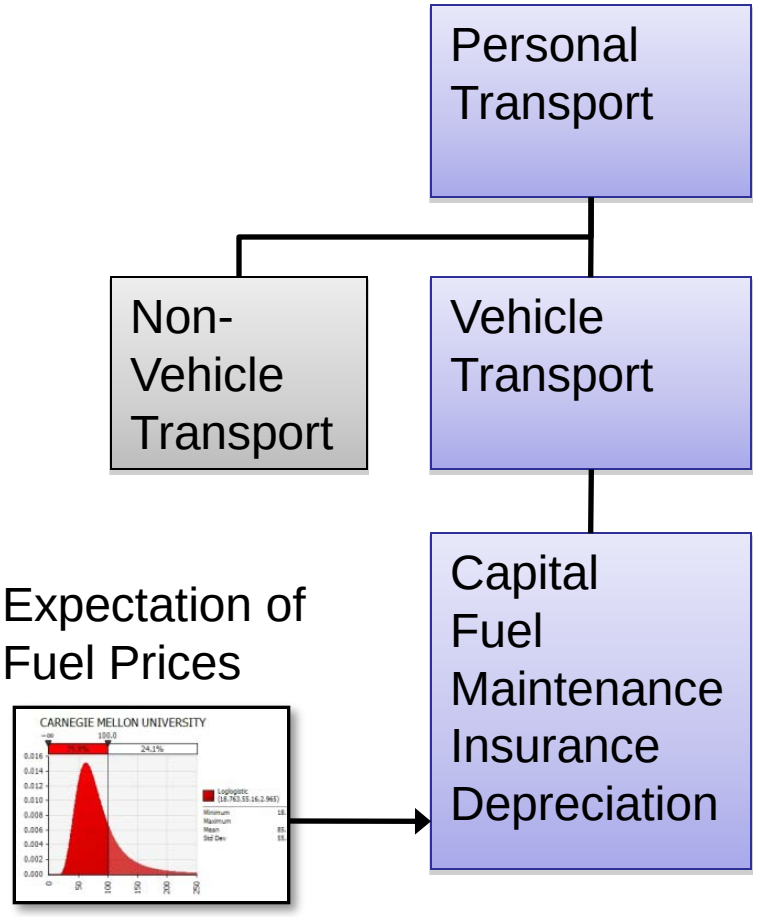
*Using AEO2009 Reference Case forecasts of fuel prices, fuel economy, and personal income.

A Rebound Effect is Observed, but..

- DOT uses a 10% rebound rate with sensitivity between 5-15%

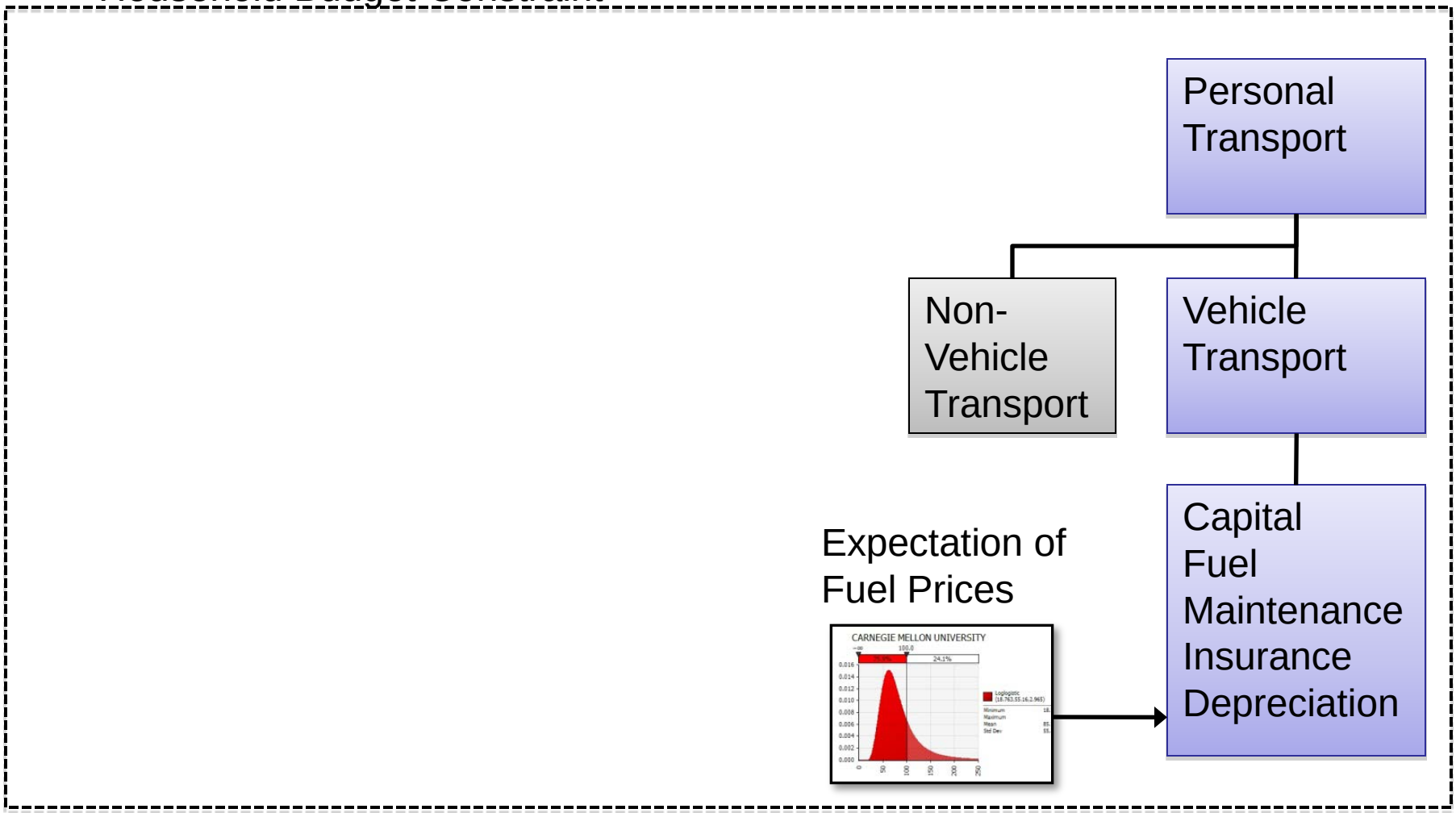
- Can we be certain that the elasticity is valid in both directions?
- Data between states, cars and light trucks and on on-road fuel economy not straightforward
- What is the saturation point and alternatives available?
- What about vehicle ownership patterns?
- Can we confirm with long-run demand elasticity for gasoline?
- How do budget constraints affect rebound?
- What if the income effects and/or marginal transportation price changes my land-use and housing decisions?

Vehicle Operating Costs are a Component of Household Budgets



Vehicle Operating Costs are a Component of Household Budgets

Household Budget Constraint



Vehicle Operating Costs are a Component of Household Budgets

Household Budget Constraint

Housing

Food and Clothing

Health

Leisure

Education

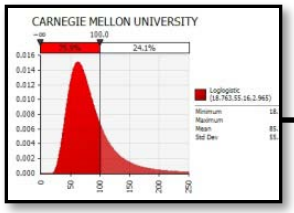
Personal Transport

Non-Vehicle Transport

Vehicle Transport

Capital
Fuel
Maintenance
Insurance
Depreciation

Expectation of Fuel Prices



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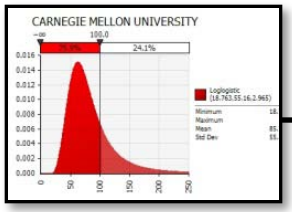
Marginal Rates of Transformation Between These Areas?

Expectation of Fuel Prices



Capital
Fuel
Maintenance
Insurance
Depreciation

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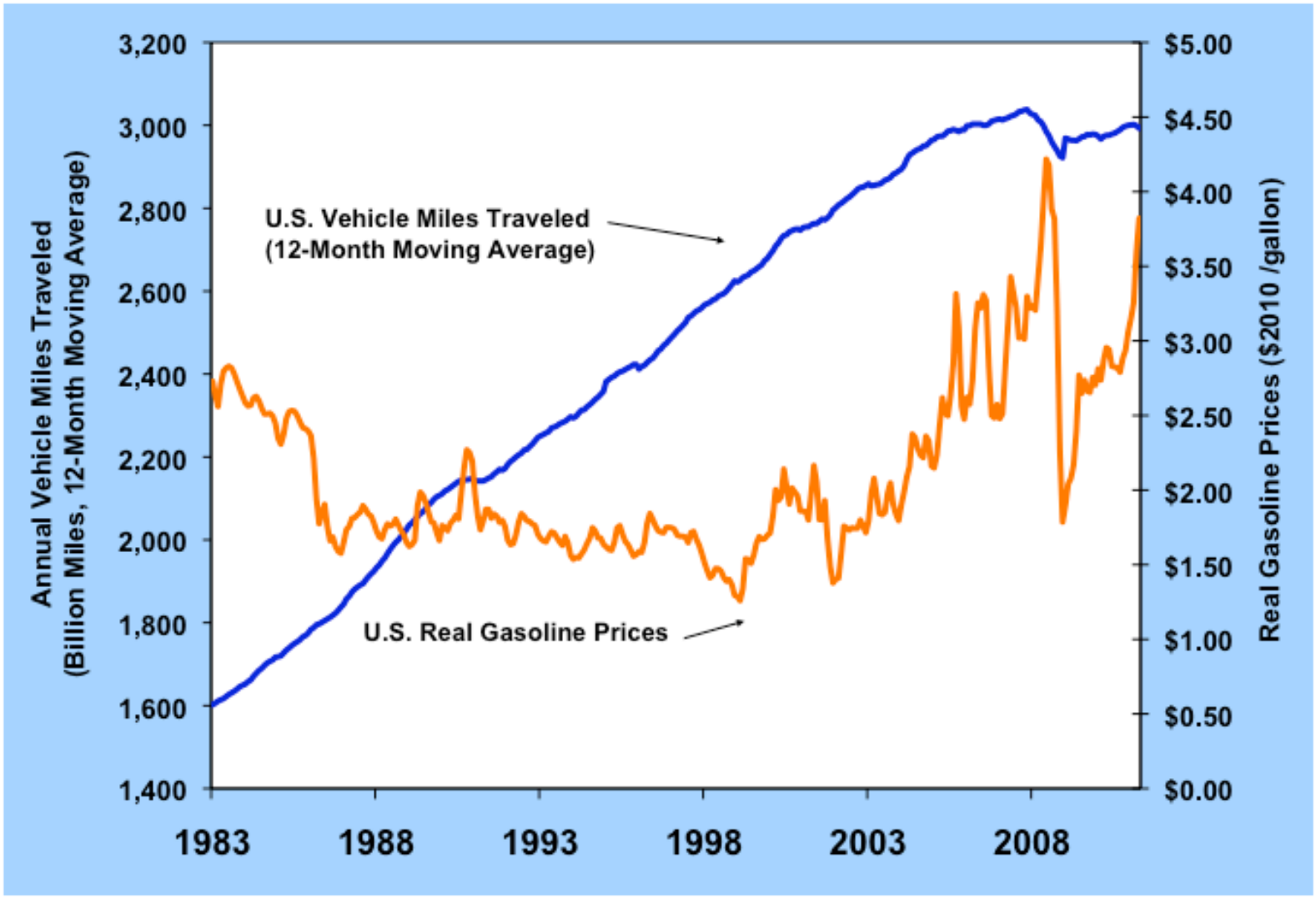
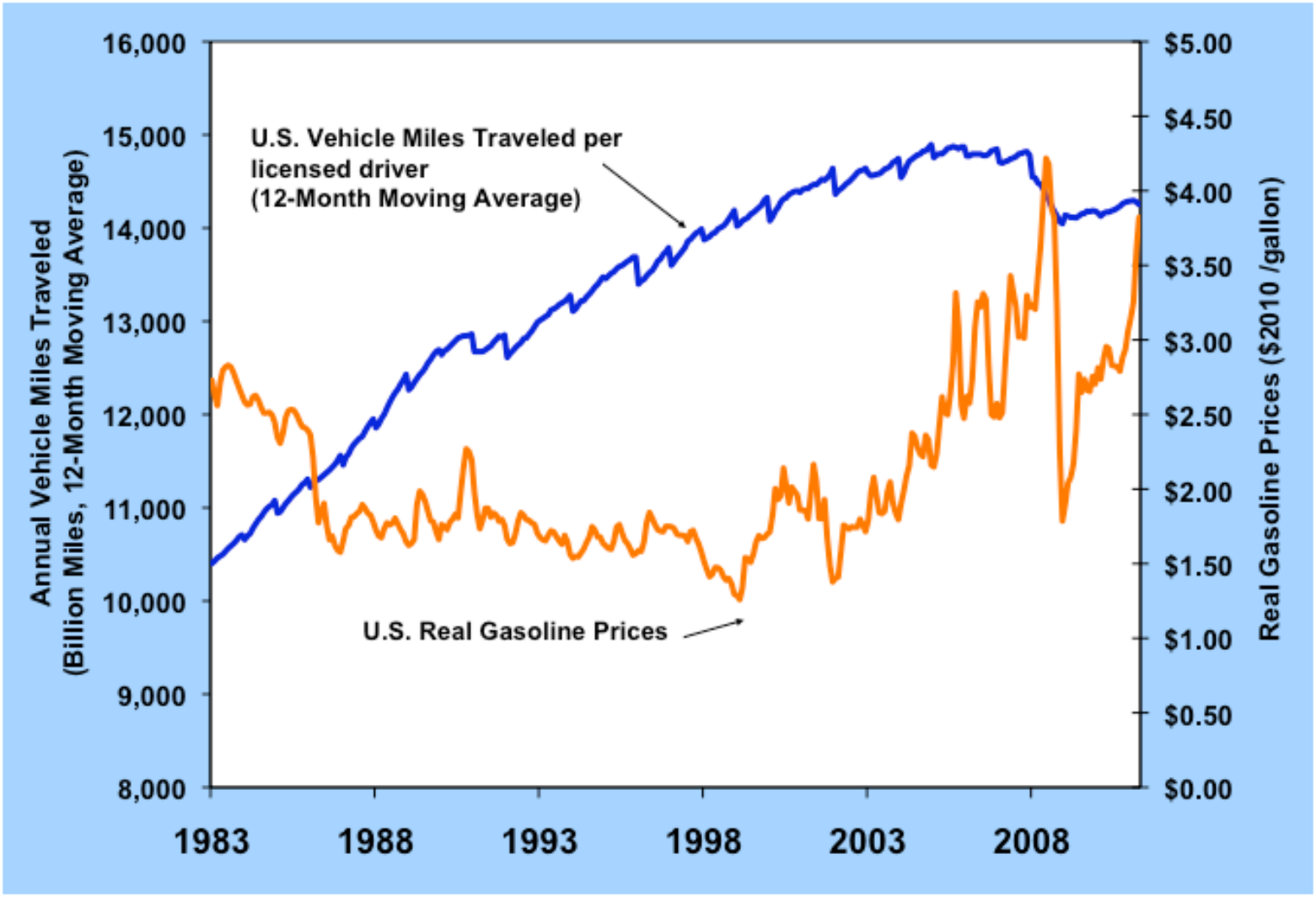
- **What is the rebound effect in transportation?**
- **What are implications for climate change?**

- **The magnitude of the rebound effect will dictate total emissions from various transportation technology choices and policies**

U.S. Vehicle Miles Traveled and Gas Price



U.S. Vehicle Miles Traveled and Gas Price Per Driver



Some Issues for Analysis

- There are two related research contexts with rebound: energy and carbon
- Given a range of rebound rates, what policies should be designed to ensure scale in GHG reductions from transportation?
  - Can we use estimates of potential transportation rebound in emerging economies to build in uncertainty and safety valves into global climate mitigation strategies?
  - Can we design robust efficiency strategies that minimize potential for surprise in total GHG emissions?

- Will reduced U.S. gasoline use affect the demand for oil internationally, and by how much?
- Will different transportation technologies have different rebound rates?
  - What rebound rates can we expect from Evs/PHEVs, biofuels, NGVs, FCVs, etc.