THE ECONOMICS OF THE ENERGY PARADOX

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A Timely Quote

- *If the United States were to make a serious commitment to conservation, it might well consume 30 to 40 percent less energy than it now does, and still enjoy the same or an even higher standard of living . . . Although some of the barriers are economic, they are in most cases institutional, political, and social. Overcoming them requires a government policy that champions conservation, that gives it a chance equal in the marketplace to that enjoyed by conventional sources of energy.*
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  - From his book Energy Future, published in **1979**.

The Win-Win Proposition

- “Energy efficiency saves money and saves the environment.”

- Two types of market failures:
  - Externalities
  - “Investment inefficiencies”

- McKinsey & Co. (2009): Profitable energy efficiency investments could return more than $100 billion per year in the U.S. alone.

Some Questions

- How would one provide evidence on investment inefficiencies?
- What does the evidence show?
- How should we make policy in light of the evidence?

Agenda

1. Background on energy efficiency policies
2. Basic economic model
3. Empirical evidence
4. Policy implications

- This presentation draws on joint work with Michael Greenstone (MIT), Sendhil Mullainathan (Harvard), Todd Rogers (Harvard), Rich Sweeney (Harvard), Dmitry Taubinisky (Harvard), and Nathan Wozny (Mathematica).

- Thanks to the Sloan Foundation and MacArthur Foundation for financial support.

Major U.S. Energy Efficiency Policies

Table 2: Significant US Energy Efficiency Policies		
Name	Years	Magnitude
Corporate Average Fuel Economy Standards	1978-	$10 billion annual incremental cost from tightened 2012 rule (NHTSA 2010)
Federal Hybrid Vehicle Tax Credit	2006-2010	$426 million total annual credit (Sallee 2010)
Gas guzzler tax	1980-	$200 million annual revenues (Sallee 2010)
Federal appliance energy efficiency standards	1990-	$2.9 billion annual incremental cost (Gillingham, Newell, and Palmer 2006)
Residential and commercial building codes	1978-	
Electricity Demand-Side Management programs	1978-	$3.6 billion annual cost (US EIA 2010)
Weatherization Assistance Program (WAP)	1976-	$250 million annual cost (US DOE 2011a)
2009 Economic Stimulus	2009-2011	$17 billion total (U.S. DOE 2011b)
Additional WAP funding		$5 billion
Recovery Through Retrofit		$454 million
State Energy Program		$3.1 billion
Energy Efficiency and Conservation Block Grants		$3.2 billion
Home Energy Efficiency Tax Credits		$5.8 billion total credit in 2009 (U.S. IRS 2011)
Residential and Commercial Building Initiative		$346 million
Energy Efficient Appliance Rebate Program		$300 million
Autos Cash for Clunkers		$5 billion

A Simple Model

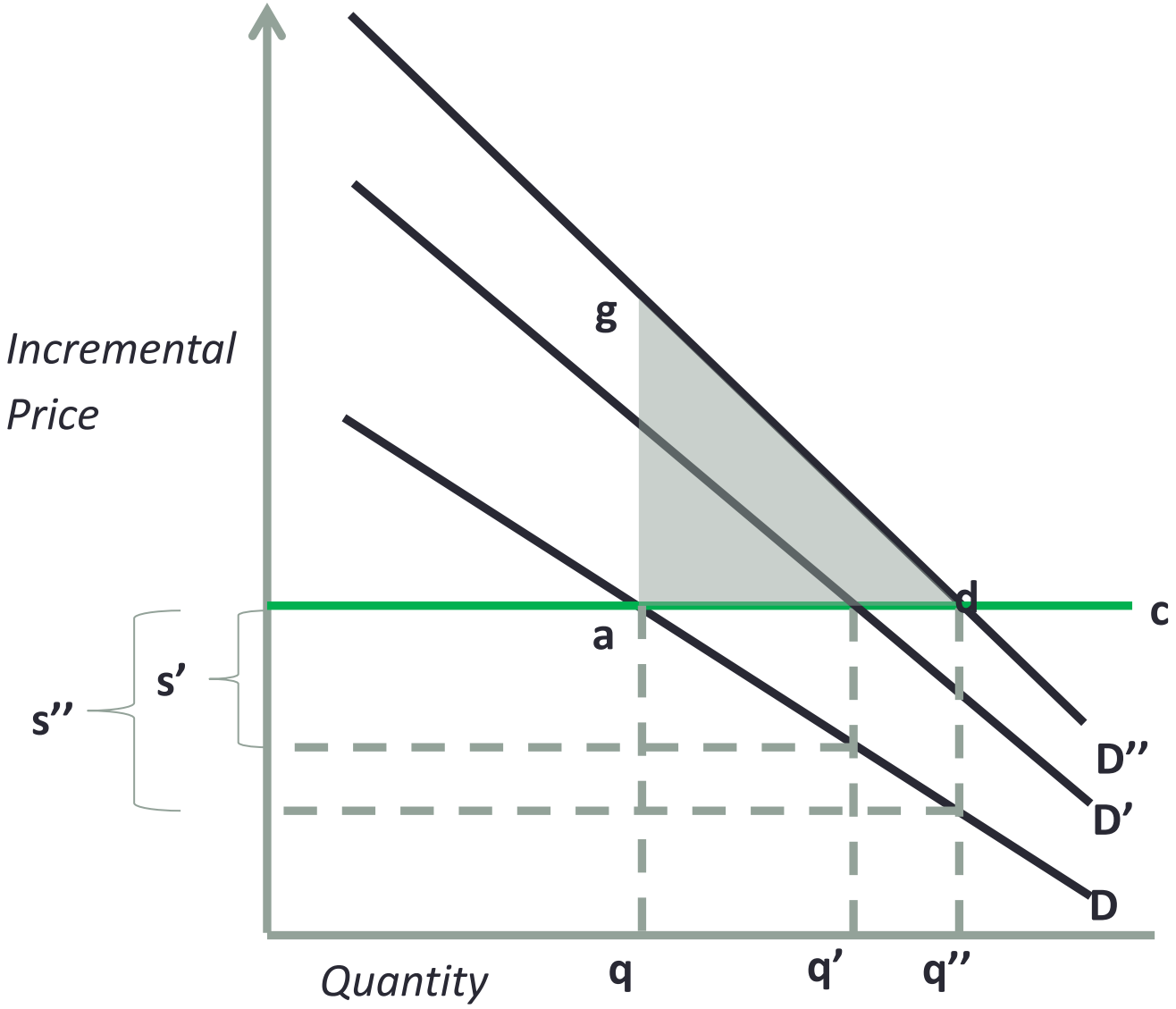
- **Two goods**: Energy efficient and energy inefficient
  - Energy intensity $e_1 < e_0$, incremental cost $c+\xi$
- Energy price p, externality ϕ.
- Energy and durables markets both perfectly competitive
- **Two periods:** Period 1: choose good. Period 2: use good
  - Social discount rate r.
- **Consumers:** Differentiated in m_i (utilization demand).
  - Potential investment inefficiency $\gamma \leq 1$. (Consumers imperfectly informed/inattentive to energy costs or are credit constrained.)
- **Social optimum:**

$$(p+\phi)m_i(e_0-e_1) / (1+r) - \xi > c$$

- **Market equilibrium:**

$$\gamma(p)m_i(e_0-e_1) / (1+r) - \xi > c$$

Basic Theoretical Framework: Graphical



Policy Diagnostic

- *If $\gamma=1$ (no investment inefficiencies):*
  - Setting an energy tax at marginal damage ϕ gives the social optimum.
    - Subsidies and standards are a very wasteful substitute for the carbon tax (Jacobsen 2010, Krupnick *et al.* 2010).
- *If $\gamma<1$:*
  - Directly address the market failure, e.g. through info provision.
  - If this is not fully effective:
    - Subsidies and standards can increase welfare: The "Internality Rationale" (Allcott, Mullainathan, and Taubinsky 2011).

- **Basic policy question: Is $\gamma<1$ or not?**
  - i.e., "Is There an Energy Efficiency Gap?"
  - Not just an academic question: The assumption of an Energy Efficiency Gap motivates billions of dollars worth of policy intervention.

Empirical Evidence on Investment Inefficiencies

Two approaches:

1. Test whether consumers fail to make profitable investments
   - Basic intuition: Hybrid car saves you $5000 in NPV. Are you willing to pay $5000 more for it?
     - If $(p)m_i(e_0-e_1) / (1+r) > c$, do you buy the energy efficient good?
   - Basic problem: Need to know entire objective function. What are ξ, m, and r?

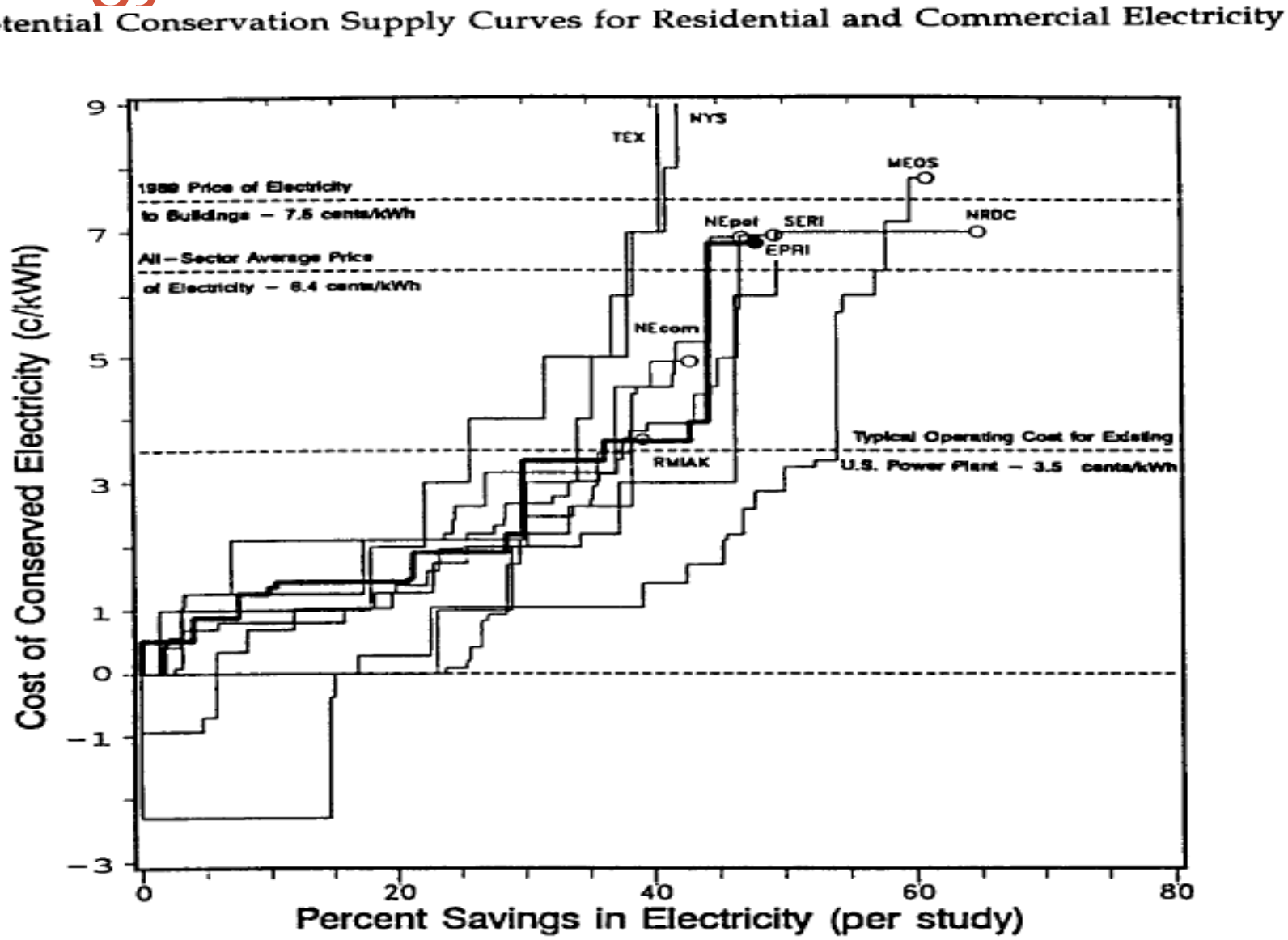
2. Test for evidence of market failures
   1. E.g. test whether consumers are well-informed about energy efficiency investments.

Historical Literature

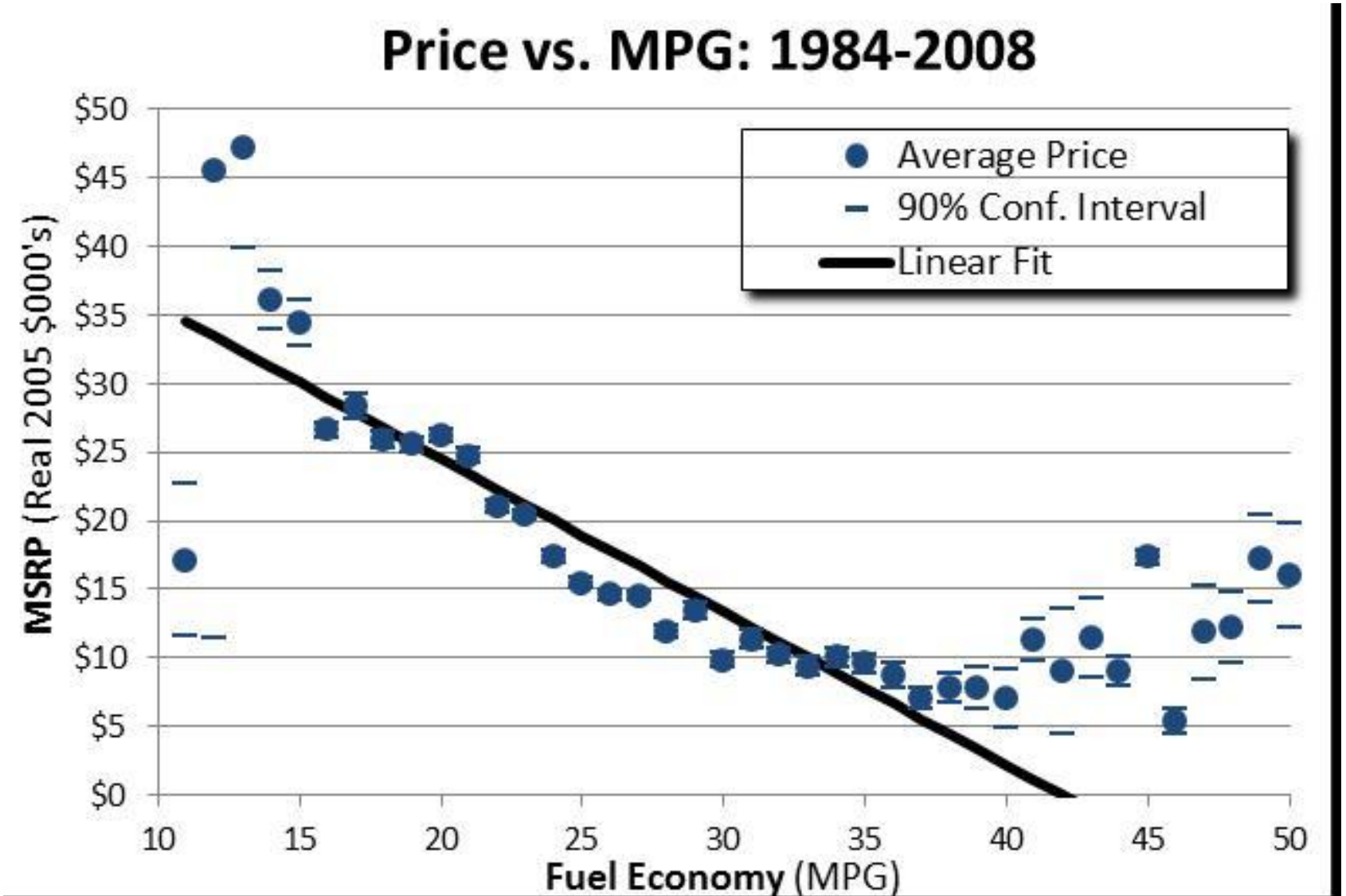
- There has been a lot of work done in assessing γ.
  - Economics: “Implied discount rate” literature (e.g. Hausman 1979, Gately 1980, Busse, Knittel, and Zettelmeyer 2011).
  - Engineering: “Energy conservation cost curves” (e.g. Meier, Wright, and Rosenfeld 1983, McKinsey 2009).

- Fundamental problems:
  - Unobserved costs.
  - What is correct PDV of energy cost savings?

Energy Conservation Cost Curve



Estimating γ with a Cross Section of Durable Goods



Empirical Examples in the Auto Industry

- Two recent empirical examples from the auto industry:
  - Allcott and Wozny (2011). “Gasoline Prices, Fuel Economy, and the Energy Paradox.”
    - Tests whether consumers fail to make profitable investments in energy efficient autos.
  - Allcott (2012). “The Welfare Effects of Misperceived Product Costs.”
    - Tests directly for evidence of a market failure: are consumers imperfectly informed?
- The auto industry is a particularly relevant and timely area to examine . . .

Cost and Benefit Estimates
Passenger Cars and Light Trucks Combined
7% Discount Rate

	MY 2012	MY 2013	MY 2014	MY 2015	MY 2016	Total
Technology Costs	$5,902	$7,890	$10,512	$12,539	$14,903	$51,748
Benefits						
Lifetime Fuel Expenditures	$7,197	$15,781	$22,757	$29,542	$36,727	$112,004
Consumer Surplus from Additional Driving	$542	$1,179	$1,686	$2,163	$2,663	$8,233
Refueling Time Value	$567	$1,114	$1,562	$1,986	$2,379	$7,608
Petroleum Market Externalities	$432	$917	$1,296	$1,654	$2,023	$6,322
Congestion Costs	($355)	($719)	($1,021)	($1,302)	($1,595)	($4,992)
Noise Costs	($7)	($14)	($20)	($26)	($31)	($98)
Crash Costs	($173)	($342)	($488)	($619)	($756)	($2,378)
CO2	$921	$2,025	$2,940	$3,840	$4,804	$14,530
CO	$0	$0	$0	$0	$0	$0
VOC	$32	$60	$80	$99	$119	$390
NOX	$53	$80	$98	$114	$131	$476
PM	$154	$336	$480	$611	$748	$2,329
SOX	$125	$265	$373	$475	$581	$1,819
Total	$9,490	$20,682	$29,742	$38,538	$47,791	$146,243
Net Benefits	$3,587	$12,792	$19,230	$25,998	$32,888	$94,495

2010 CAFE FRIA

Total Benefits:
$146 billion

Externalities:
$18 billion

“Internalities”:
$128 billion

Net Benefits:
$94 billion

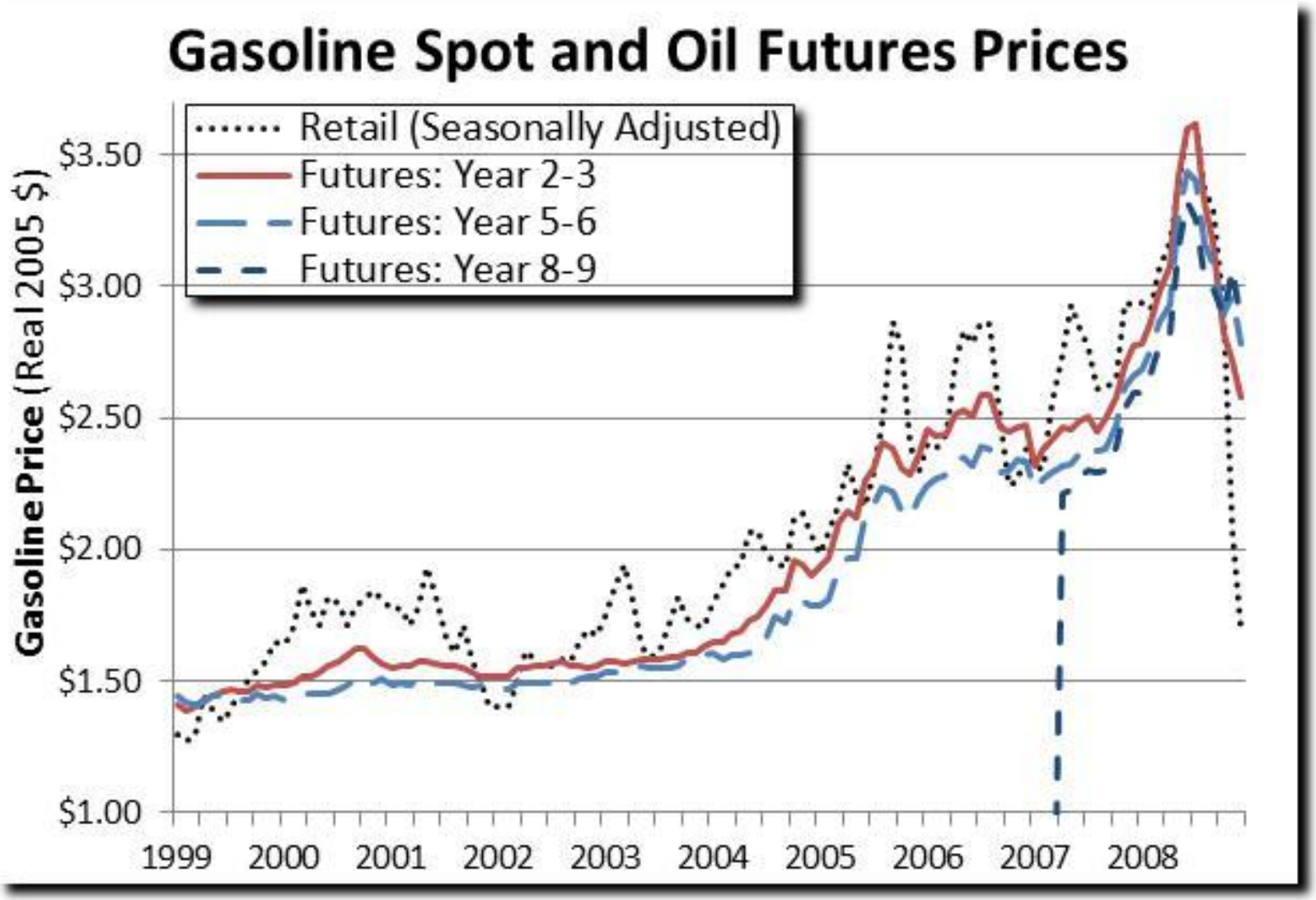
Net Benefits (w/o Internalities):
$ -33 billion

NHTSA's Introduction

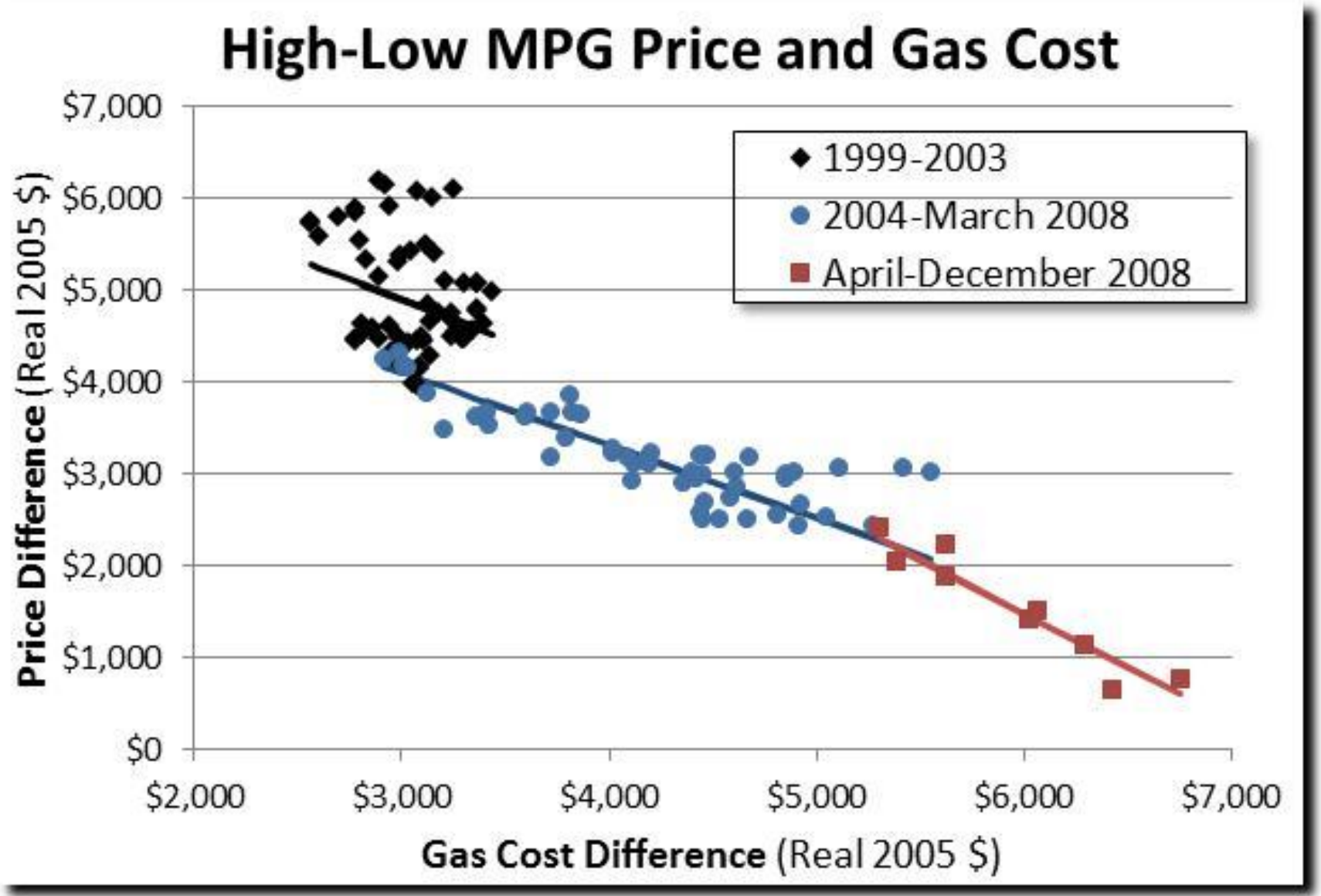
"Although the economy-wide or "social" benefits from requiring higher fuel economy represent an important share of the total economic benefits from raising CAFE standards, NHTSA estimates that benefits ***to vehicle buyers themselves*** *[original emphasis] will significantly exceed the costs of complying with the stricter fuel economy standards this rule establishes . . . However, this raises the question of why current purchasing patterns do not result in higher average fuel economy, and why stricter fuel efficiency standards should be necessary to achieve that goal. To address this issue, the analysis examines possible explanations for this apparent paradox, including discrepancies between the consumers` perceptions of the value of fuel savings and those calculated by the agency . . . "*

-CAFE Standard Final Regulatory Impact Analysis (2010)

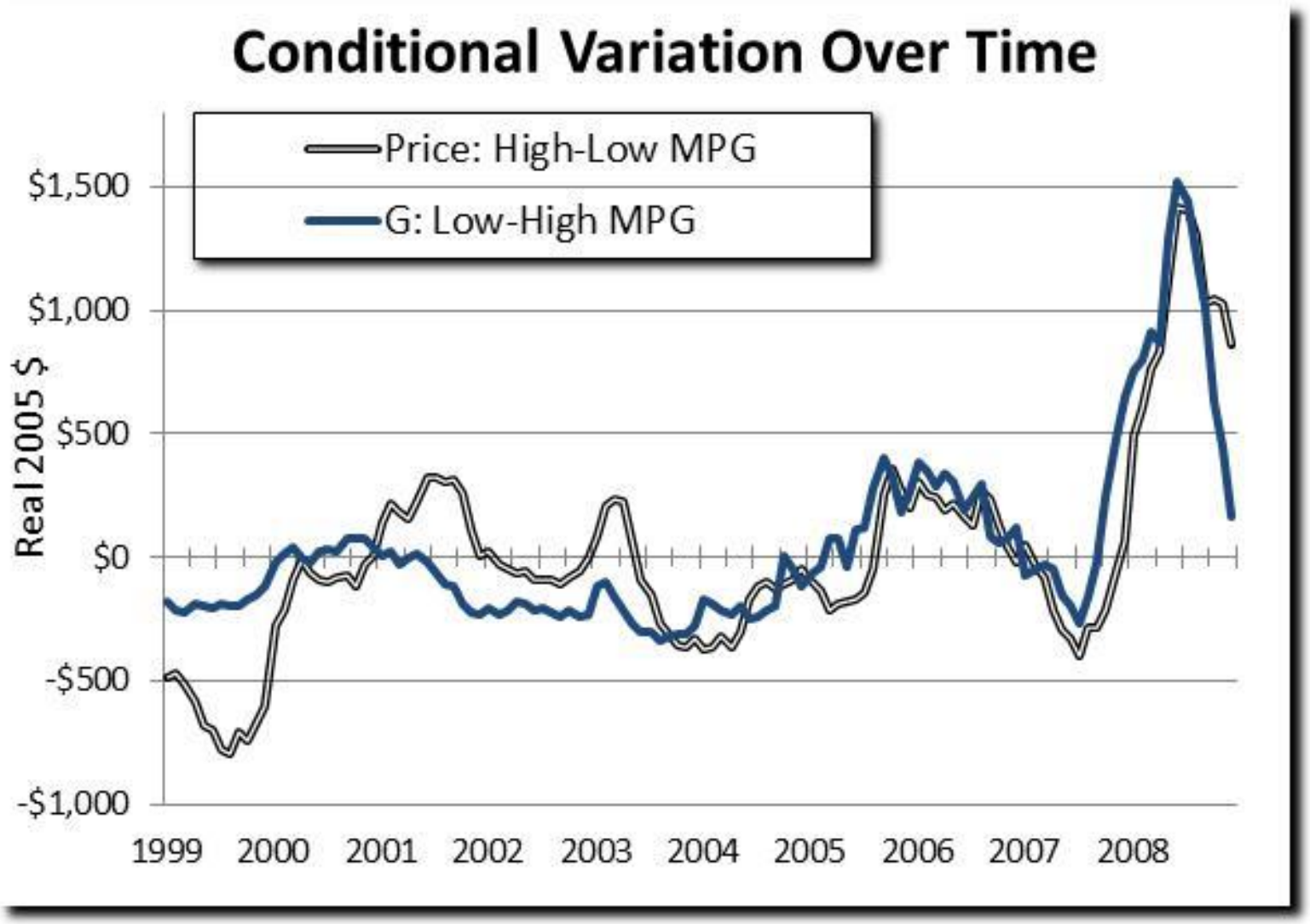
Allcott and Wozny (2011): Exploiting Time-Series Variation in Gas Prices



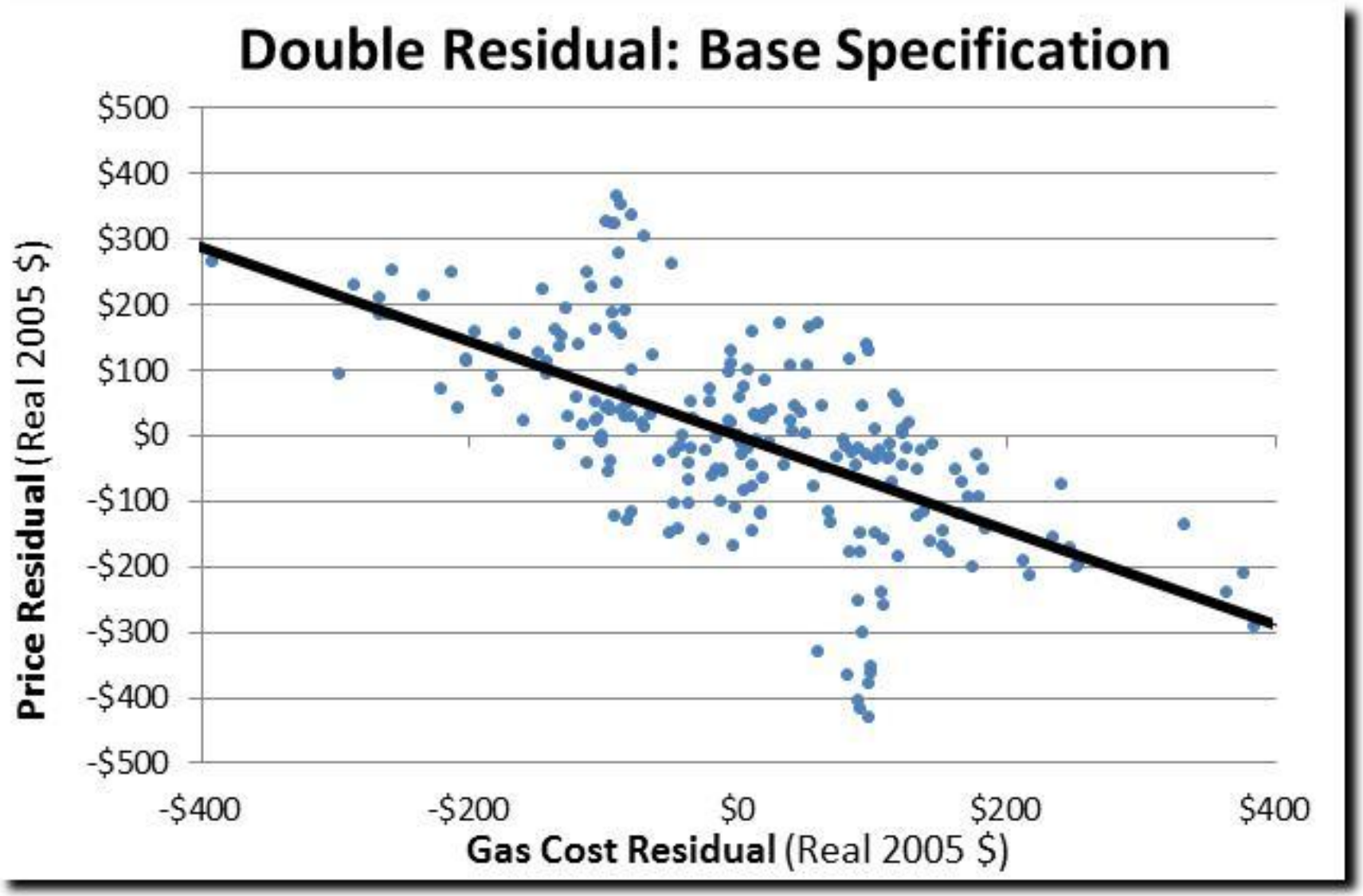
How Auto Prices Adjust



Variation Net of Controls



Partial Regression Plot



Empirical Results

- The specification we believe the most suggests $\gamma = 0.72$.
  - Caveat that alternative specifications make a difference.
    - E.g. discount rates, time period analyzed
  - Busse, Knittel, and Zettelmeyer (2011) and Sallee, West, and Fan make different assumptions. These matter.

- Is this from inattention or biased beliefs?

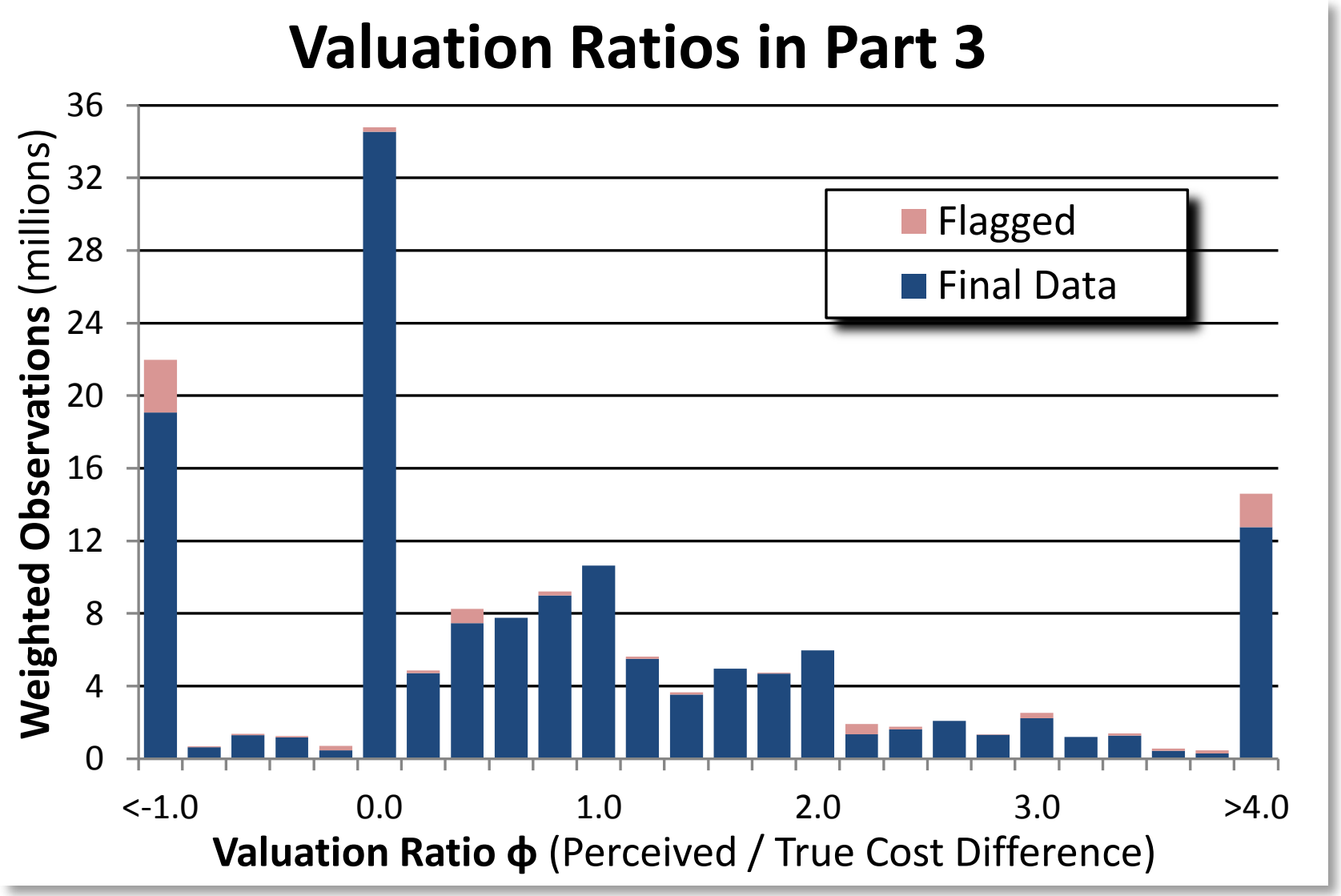
Testing for Imperfect Information

- Vehicle Ownership and Alternatives Survey
  - Funded by NSF and Sloan Foundation

- Nationally-representative survey collecting demographics, auto ownership, and beliefs about potential savings/costs from higher/lower fuel economy vehicles.

- Very basic test of imperfect information: simply ask consumers!

We Are Poorly Informed About Gas Costs



No Robust Evidence on Systematic Bias

Least Squares

	All	Part 3	Part 4	Low Outliers	All Outliers
	(1)	(2)	(3)	(4)	(5)
Const.	1.14	0.88	1.33	1.42	1.14
	(0.06)**	(0.12)	(0.06)***	(0.05)***	(0.03)***
Obs.	3290	1415	1875	3076	2971

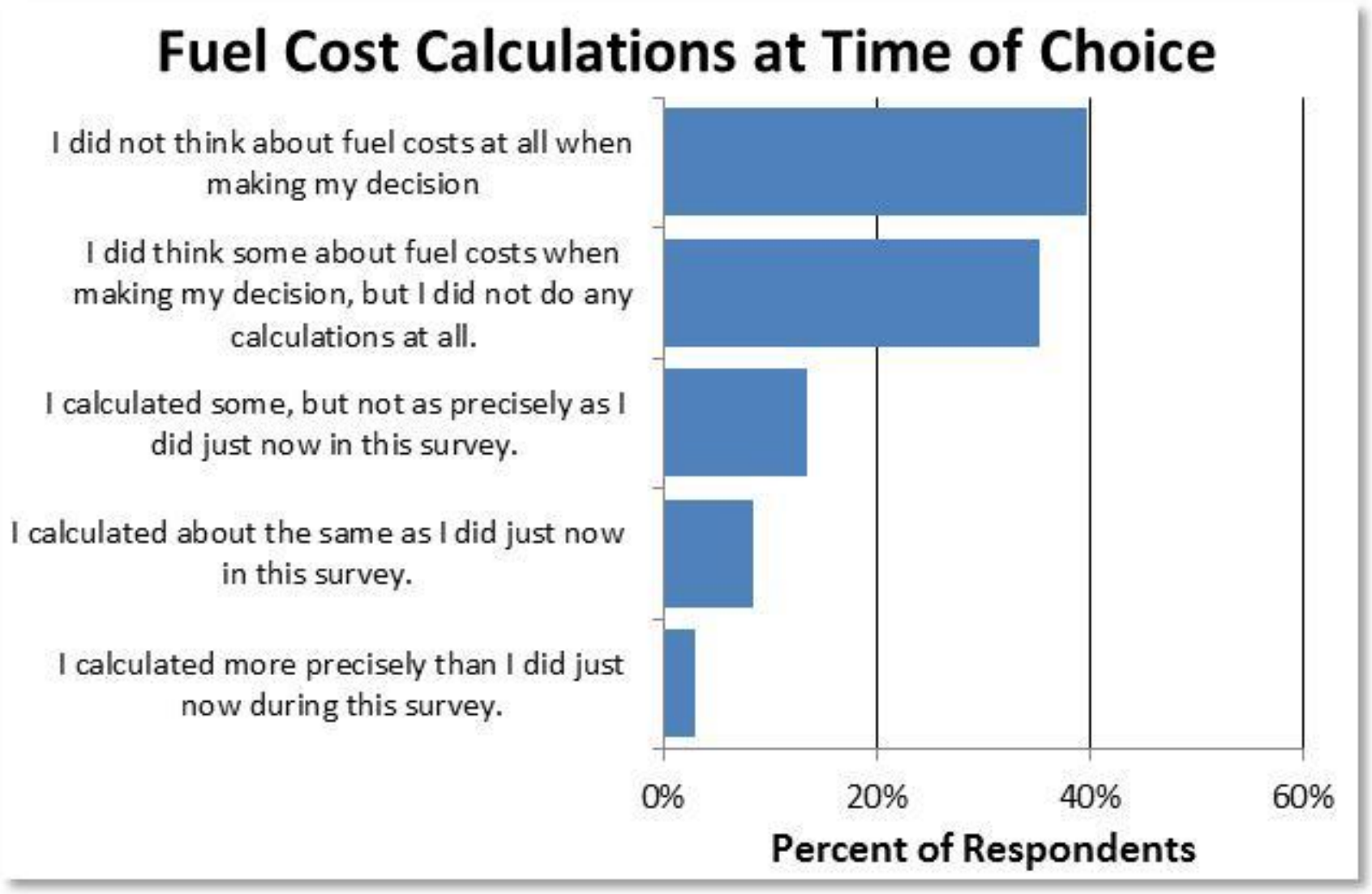
Quantile Regression at the Median

	All	Part 3	Part 4	Low Outliers	All Outliers
	(1)	(2)	(3)	(4)	(5)
Const.	0.94	0.7	1.00	1.00	0.97
	(0.02)**	(0.07)***	(0.009)	(0.01)	(0.02)*
Obs.	3290	1415	1875	3076	2971

Dependent Variable: ϕ_{ia}.

Notes: Excludes flagged observations. Weighted for national representativeness. OLS regression standard errors robust and clustered by *i*. *, **, ***: Statistically different *from unity* with 90, 95, and 99 percent confidence, respectively.

We Don’t Think Much About Fuel Costs



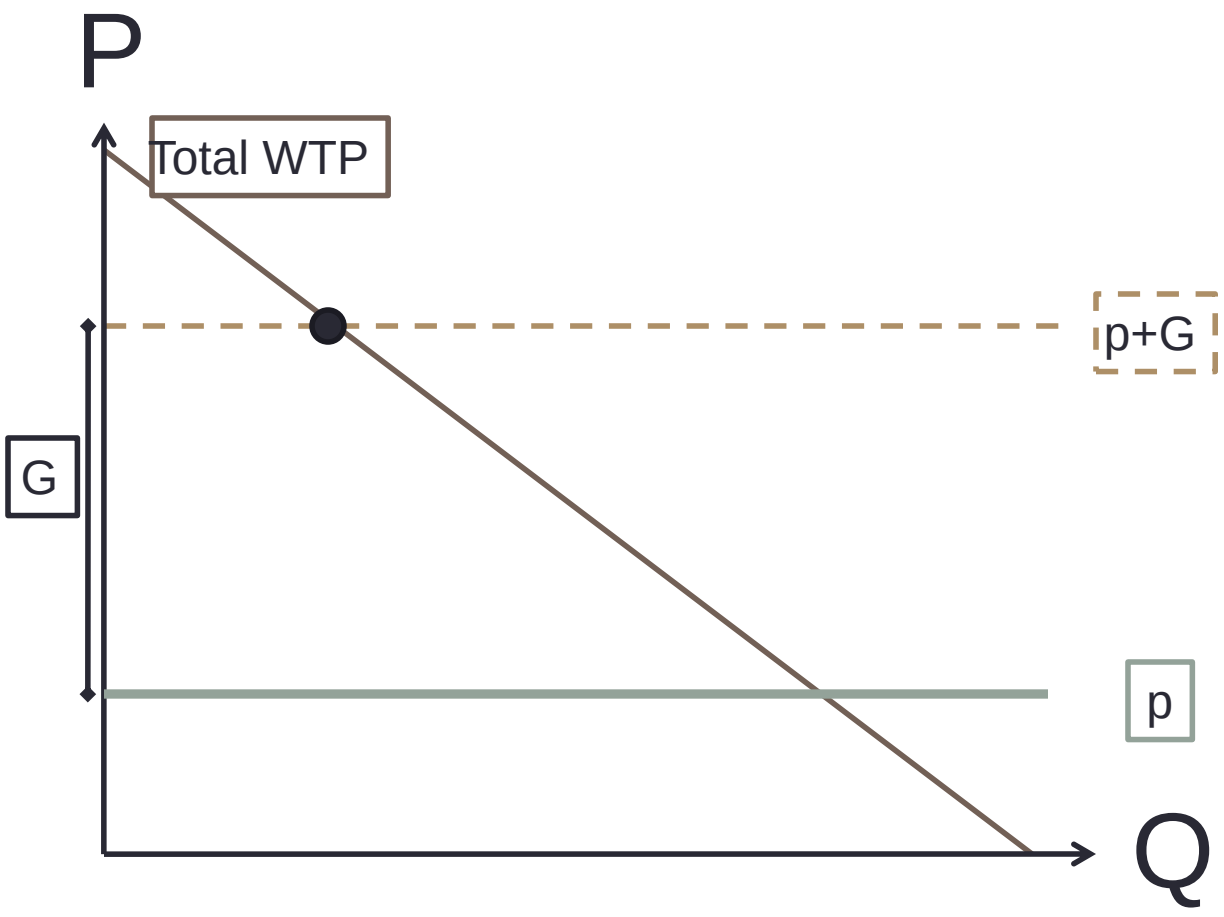
Modeling Welfare Effects

- If we think that consumers are inattentive to gas costs, what are the welfare implications?
  - i.e., how to think rigorously about the “internality benefits” from paternalistic policies such as hybrid vehicle subsidies, CAFE standards, and gas guzzler taxes?

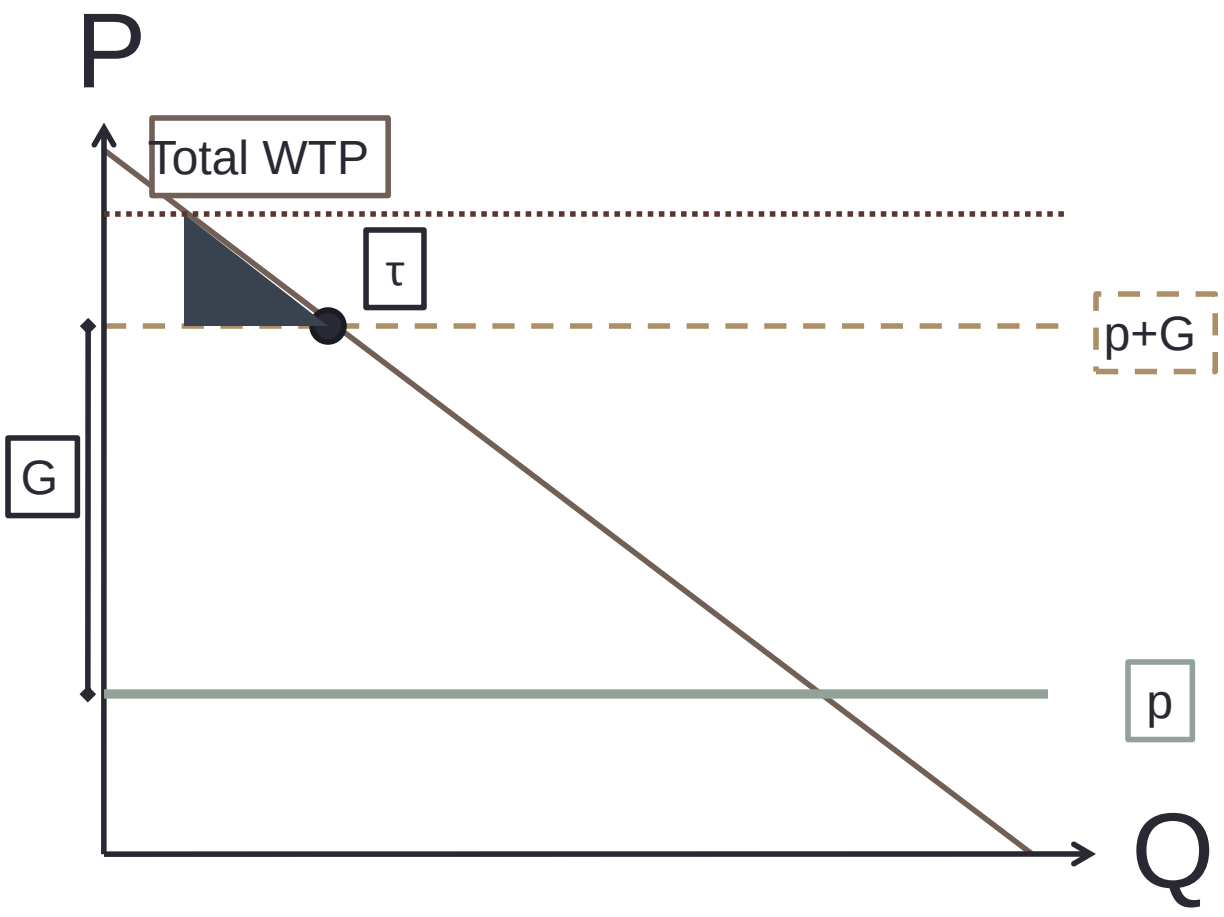
- Approach builds on Bernheim and Rangel (2009)
  - Basic problem in behavioral welfare analysis: revealed preference no longer reflects experienced utility.

- Technical details in Allcott and Wozny (2011) and Allcott, Mullainathan, and Taubinsky (2011).

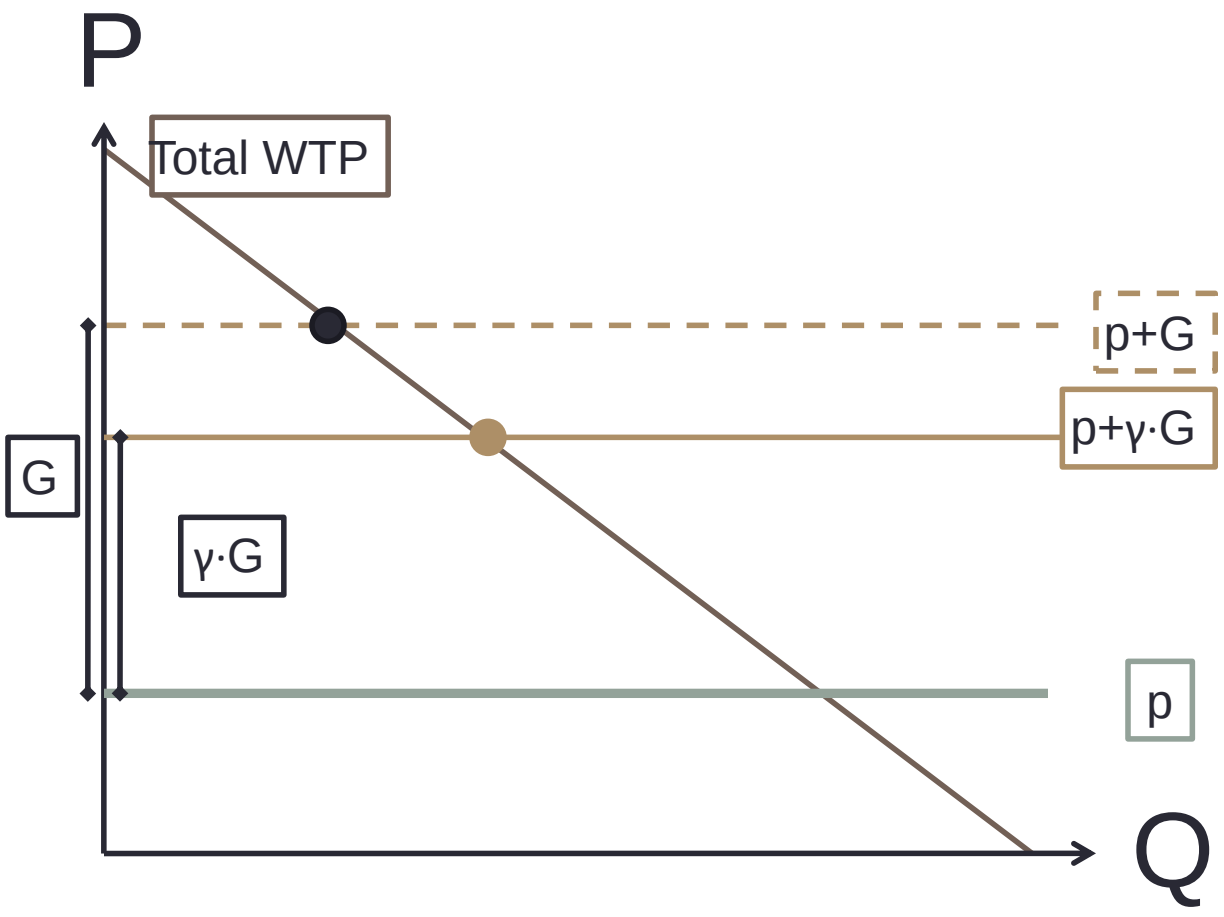
Willingness to Pay for a Gas Guzzler



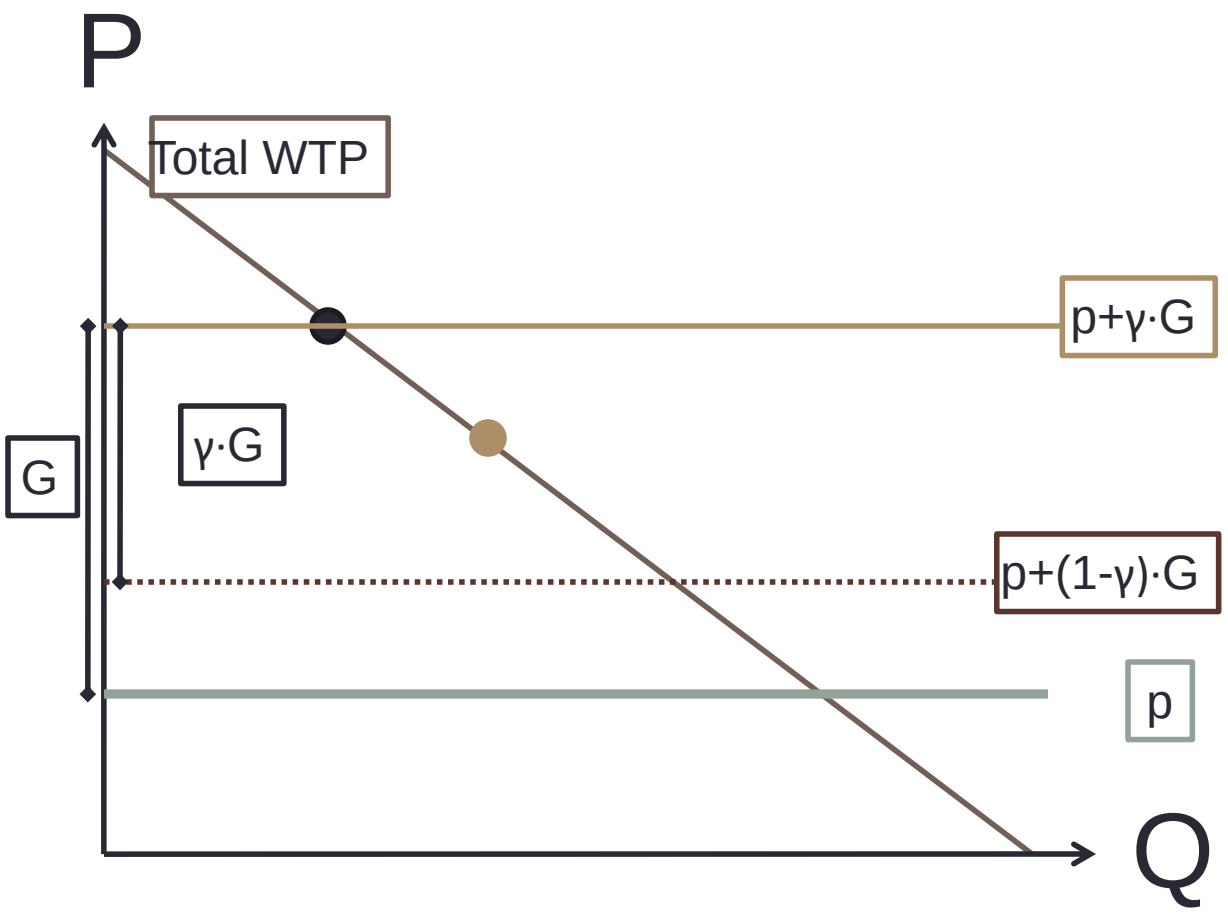
Rational Model: Effect of Gas Guzzler Tax



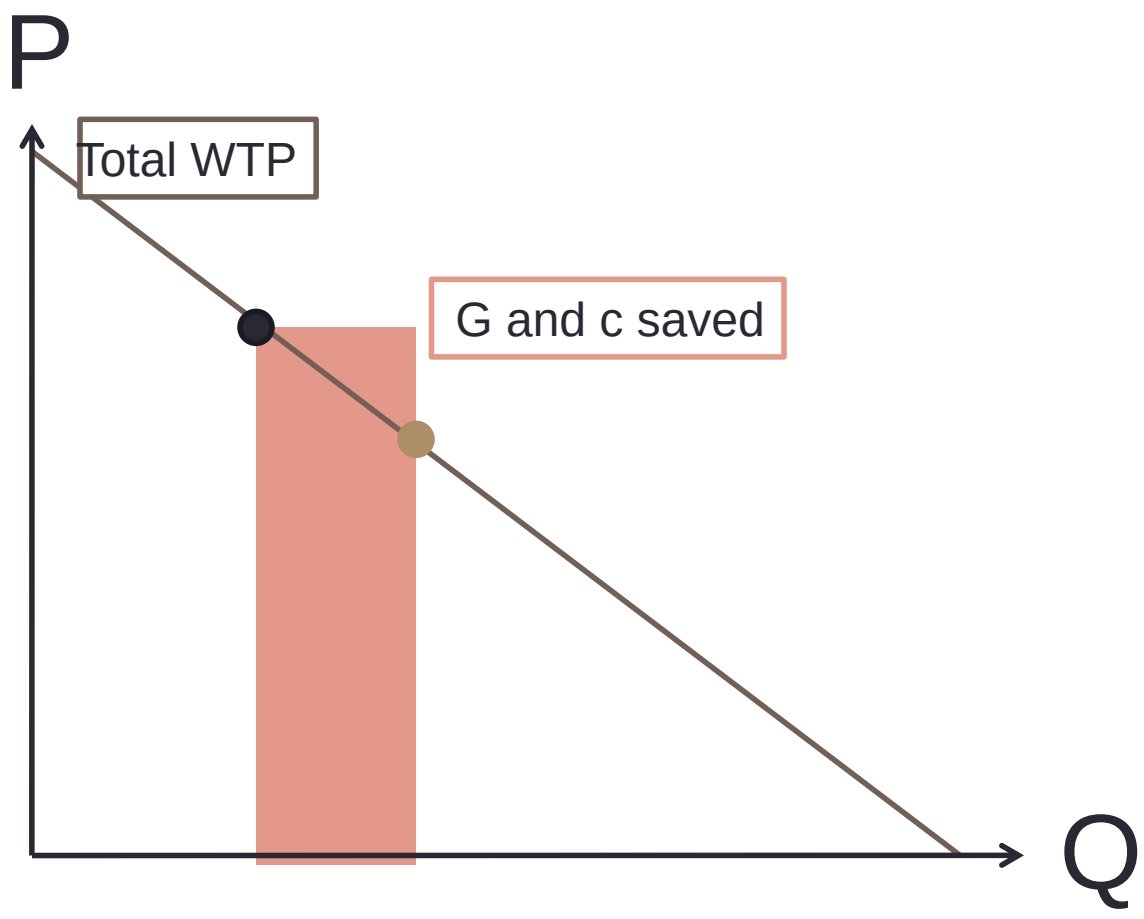
Equilibrium Under Inattention



Effect of Gas Guzzler Tax Policy



Welfare Implications



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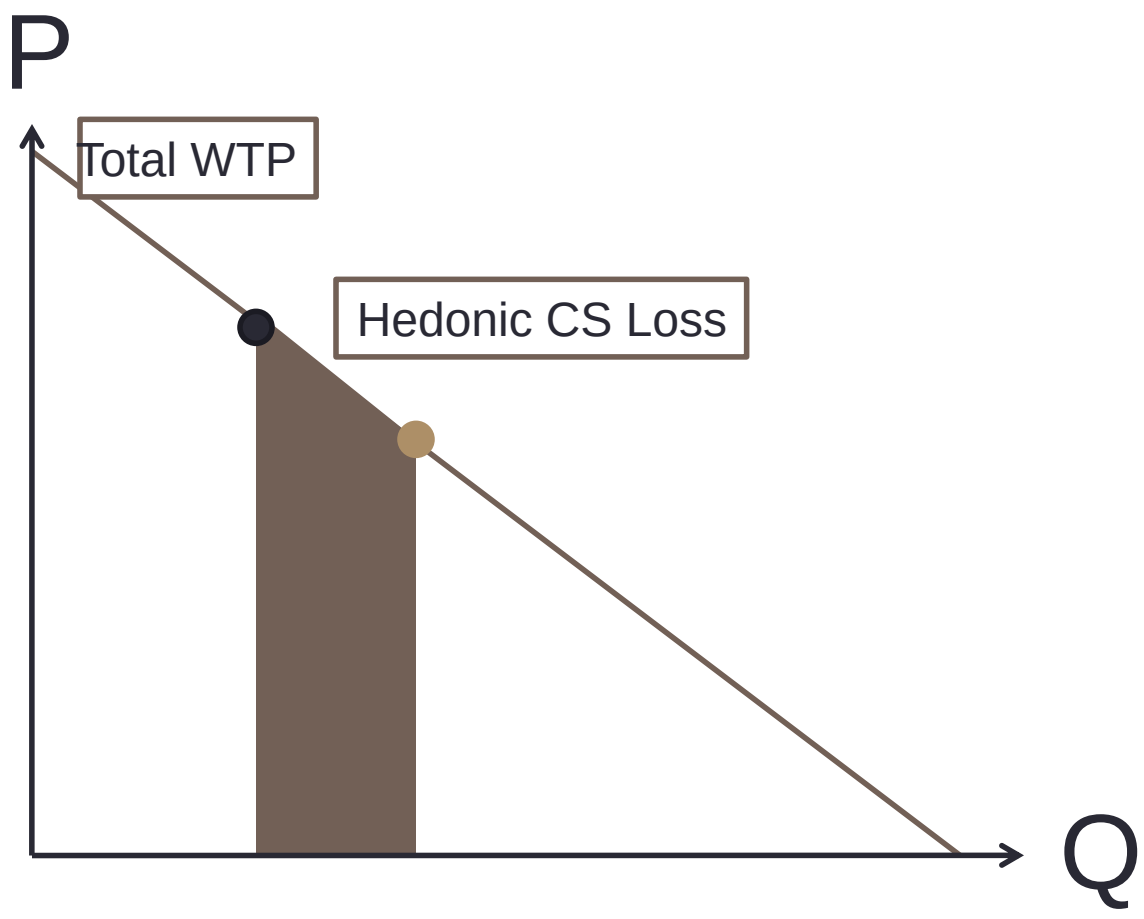

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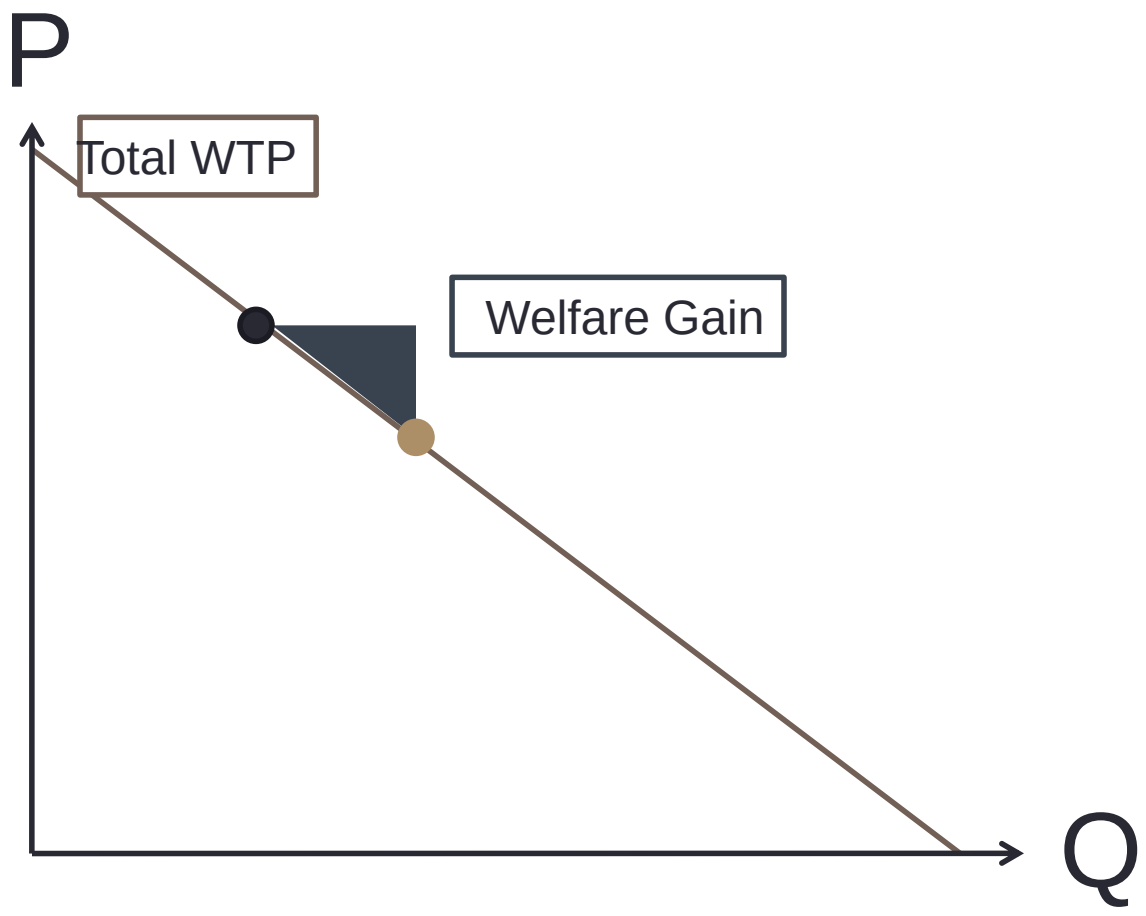


Observations

- Many people think that CAFE standards are about reducing externalities.
- CAFE Regulatory Impact Analysis: the internality (paternalistic) rationale for CAFE is potentially much more important from a welfare perspective.
- Basic intuition/calibration:
  - At $21 per ton CO2 (US Gov't 2010): Uninternalized externality from climate change is $0.18 per gallon, or 5-10% of gas price
  - "Some analysts" think that consumers undervalue gasoline costs by 20-30%.
  - Both externalities and "internalities" cause consumers to purchase too many gas guzzlers relative to the social optimum
  - But the internality effect could be 2-6 times larger!

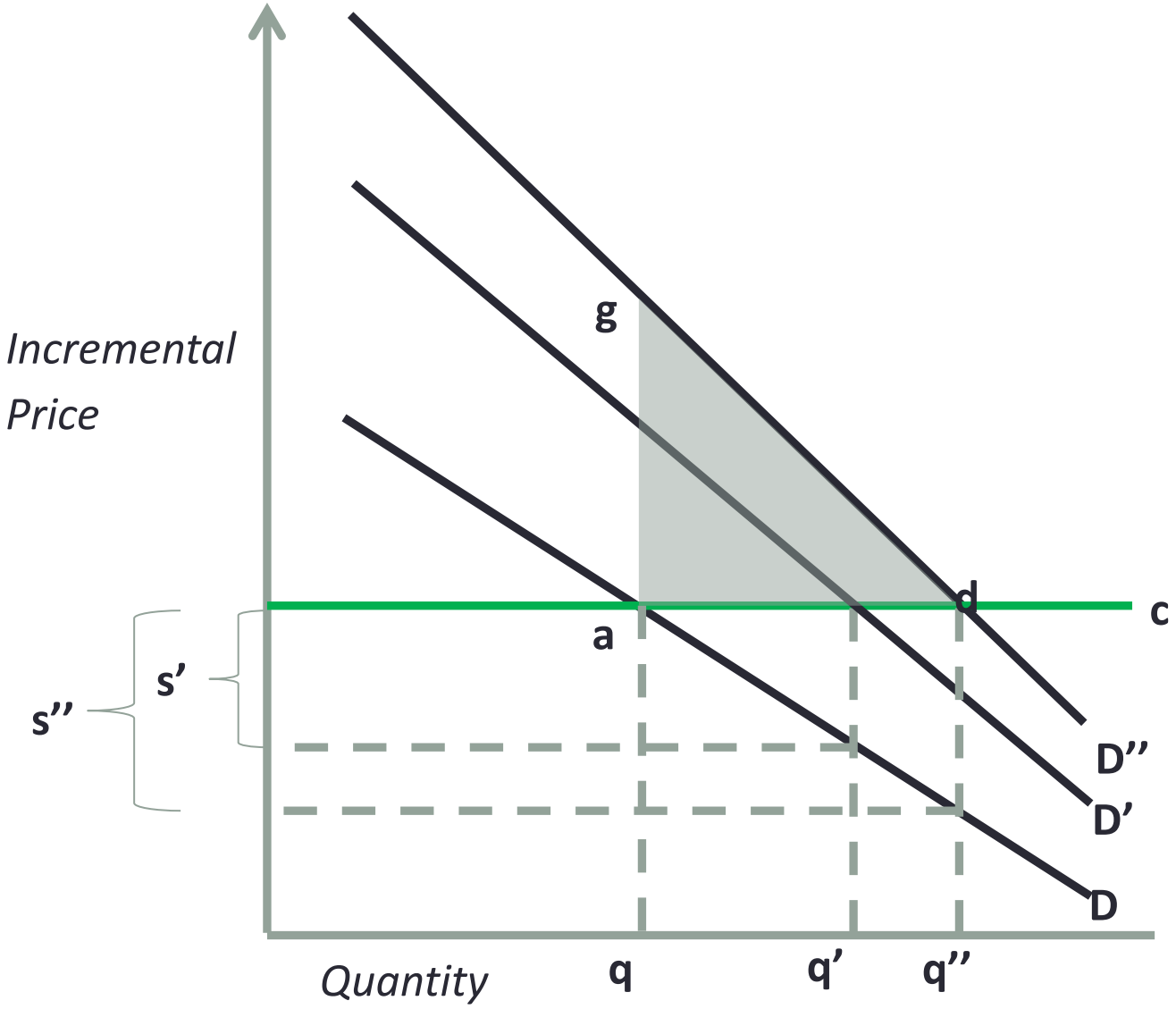
Observations (2)

- Externalities are not the primary rationale for regulating internalities.
  - $21 per ton CO_2 compared to energy price.
  - So if you want to encourage energy efficiency, you should do so as a paternalist, not as an environmentalist.
  - Most utilitarians OK with this.
- Many of the investment inefficiencies (inattention, credit constraints, imperfect information, landlord-tenant) affect many many goods other than energy. Why devote so much extra attention to energy?

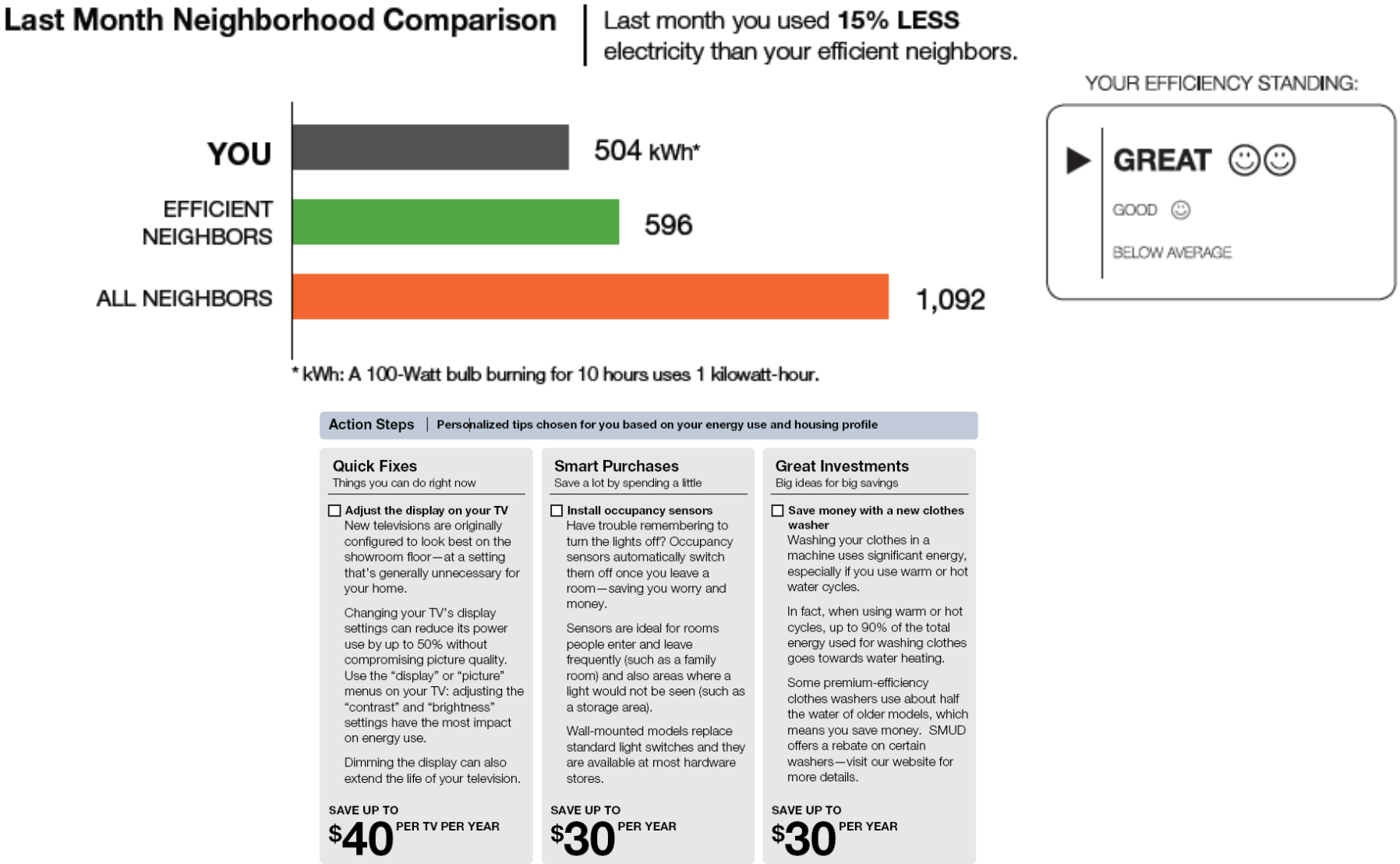
Observations (3)

- Heterogeneity in γ means that targeting is important.
  - Examples: landlords/tenants, greens/inattentives, liquidity constrained/liquid.
  - Graphical illustration on next slide
- Negative example: Utility energy conservation subsidies
- Positive example: OPOWER.

Basic Theoretical Framework: Graphical



OPOWER Home Energy Reports



Unanswered Questions

- Measuring γ in different settings
  - How do consumers (and businesses) actually value energy efficiency? Cars? Factories? Universities? Toaster ovens?
- If $\gamma<1$, understanding why.
  - Inattention, beliefs, credit constraints?
- Rigorously understanding policy implications.
- What is the role of the firm?
  - Manufacturers and retailers can nudge consumers toward or away from the energy efficient product. How well are they doing this? What are their incentives? How can we change them?

Takeaways

- **As with all environmental problems, the objective can't possibly be to "conserve at any cost."**
  - Most effective way to conserve energy: shut off all power plants!
- **We are better off only when we conserve iff the benefits outweigh the costs.**
  - Energy efficiency is an example: Buy hybrids/Energy Star only when benefits outweigh costs.
  - Much of the progress in this area is in rigorously assessing when this is the case.
- **Ways to improve policy**
  - Subsidies/standards are a very wasteful "backdoor carbon policy."
  - Subsidies/standards only if solid evidence that $\gamma<1$.
  - Target policies more directly at the investment inefficiencies.