### Automotive Fuel Economy: The Case for Market Failure

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### Who cares?



- Global climate change
- Energy security
  - OEconomic losses in hundreds of billions/year
  - OSignificant military and foreign policy costs

#### Oil Peaking

- OEase the transition
- OBuy time to develop sustainable alternatives

What makes us think there's a market failure?

The usual suspects are present... OTransaction costs OBounded rationality OPrincipal agent problem Imperfect information But sufficient are... Ouncertainty & Loss aversion

# Consumers are, as a general rule, LOSS AVERSE.

- Will decline a bet with even odds of winning \$110 or losing \$100.
- Gal (2006) shows that loss aversion can be derived from two simple postulates:
  - OConsumers require a motive to act
  - Consumers have imprecise (fuzzy) preferences

# Consumers with fuzzy preferences will be indifferent over a potential payoff range.



A preferred to B Indifference Range: Status Quo Preferred B preferred to A

Increase in absolute attractiveness of risky bet

#### Preferences about the future are inherently fuzzy.

Numerous studies and experiments have confirmed the loss aversion principle. Kahneman and Tversky (1992) have fitted the following loss aversion function to empirical data.

 $u(x) = \left\{ \begin{array}{l} x^{\alpha} & \text{if } x \ge 0 \\ -\lambda(-x)^{\beta} & \text{if } x < 0 \end{array} \right.$ 

 $\lambda = 2.25$   $\alpha = \beta = 0.88$ 

## Assuming certainty and precise preferences, a 25% increase in MPG would be optimal.



Uncertainty about several key elements of the net present value calculation makes an expenditure on higher fuel economy a *risky bet*.

- Sure, there's a fuel economy label on every car but what MPG will *I* get?
- How long will my car last?
- How much driving will I do?
- What will gasoline cost?
- What will I have to give up to get better fuel economy? (How much will it cost?)

Based on MPG estimates submitted by 15,000 motorists, 2 std. dev. around the EPA's (old) estimate is +/- 7.4 MPG.



# Quantifying the uncertainty defines the consumer's risky bet.

- Fuel economy: <u>www.fueleconomy.gov</u> "Your MPG" database: +/-7MPG = 95% C.I.
- Cost: NAS (2002) High/Ave./Low cost curves
- Vehicle lifetime: ORNL TEDB scrappage curves
- Vehicle use: +/- 10% of NHTS average
- Fuel price: EIA AEO 2007 Hi/Ref/Low Oil Price Cases
- Rates of decline in vehicle use, return on investment, are constant, NAS assumptions.

A Monte Carlo simulation indicates that the fuel economy bet has an *expected value* of \$405.



Applying Kahneman and Tversky's typical consumer loss aversion function changes the value of the fuel economy bet to -\$32.



Net value seems to be most sensitive to uncertainty about real world fuel economy.



If the average consumer would decline the fuel economy bet, why would a manufacturer redesign and retool its entire product line, investing billions of dollars to offer it? We believe the uncertainty/loss aversion market failure explains the fundamental economic behavior that causes the market to produce less fuel economy than is economically efficient.

- Consumers do not see the fuel economy technology trade-off.
- What consumers see in the market are trade-offs with performance, size, and luxury (high fuel economy = cheaper).
- Nonetheless, the fundamental economics remain valid.
- Manufacturers see the fuel economy technology cost trade-off and evaluate it based on what they think consumers are willing to pay for.

#### Surveys confirm consumers not interested in MPG.

#### U.S. – Turrentine & Kurani 2004

- In-depth interviews of 60 California households' vehicle acquisition histories found *no evidence* of economically rational decision-making about fuel economy.
- Out of 60 households (125 vehicle transactions) 9 stated that they compared the fuel economy of vehicles in making their choice.
- None had made any kind of quantitative assessment of the value of fuel savings.
- May 2007 DOE/NREL ORCI national random sample survey.
  - 39% did not consider fuel economy in their last vehicle purchase.
  - Only 14% mentioned considering MPG in economic terms.
- Europe European Attitudes Towards Urban Traffic Problems and Public Transport – Survey Report for the Commission of the European Communities and the UTIP, INRA (Europe) European Coordination Office sa, July 1991
  - "Most EC citizens (60%) agree with the statement: 'Up till now, changes in petrol prices have not altered my use of the car.', but 23% of the Europeans state that they have changed their behaviour."

# When asked the payback question, consumers respond in accord with manufacturers' perception.



The implications of a 3-year payback requirement and uncertainty+loss aversion are the same.



Since 1987 (CAFE standards constant since 1985) technological advances have been used to improve attributes other than fuel economy.

Car Data from EPA's 2006 FE Trends Report



Fuel efficiency has increased by about 1.3% per year since 1987 However, this has all been used to increase other attributes more highly valued by the customer, such as performance, comfort, utility, and safety One implication of the uncertainty/loss aversion market failure is that gasoline price will be a relatively ineffective lever for increasing fuel economy.



International Energy Annual 2005, Released June-July 2007, Table 11.8

#### 1993 US-Europe Engine Comparison



Despite fuel prices about 3 x those in the US:

- Horsepower/liter, torque/liter, compression ratio (CR), and % OHC were virtually identical
- U.S. had more multi-valve engines and more sophisticated fuel metering

#### A 1998 IEA study showed that fuel economy technology adoption was about the same in the U.S., Germany and Denmark, despite very different fuel prices.



Source: Saving Oil and Reducing CO2 Emissions in Transport, IEA, 2001

Even 3 years into the European CO2 requirements and despite 3 x fuel prices in Europe, US technology still matches that of Europe.



Policies and Measures to Mitigate GHG emissions: Transportation Options (LDV) Technical Appendix, IEA, March 2000 The uncertainty/loss aversion market failure has profound implications for transportation energy policy.

- Yes, there is a market failure and it does result in significantly lower fuel economy than is optimal even from the consumer's perspective.
- Policies like fuel economy standards and feebates will be more effective than gasoline or carbon taxes because they remove or reduce uncertainty.
- We note that higher fuel prices are still an important strategy and justified because of the important externalities of petroleum fuel use.
- We also note that the uncertainty/loss aversion market failure probably applies to the energy efficiency of all energy using consumer goods.



## THANK YOU.

#### 1993 US-Europe Engine Comparison

#### World Engines 1993, Ward's Communications

4-cylinder passenger car engine characteristics

Not sales	weighted
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		Average (not sales weighted)								Fuel Metering			
	#	Disp	HP	Torque	hp/L	ft-lb/L	CR	% OHC	% 4v	Port	Single/unk Fl	Carb	
France	39	1633	102	108	62.7	66.0	9.3	85%	13%	31%	28%	41%	
Germany	44	1755	105	113	59.6	64.3	9.5	100%	9%	86%	5%	9%	
England	17	1724	106	116	61.7	67.6	9.6	88%	47%	6%	71%	24%	
Italy	21	1341	76	83	56.8	62.2	9.2	76%	10%	33%	33%	33%	
Sweden	11	1976	122	134	61.9	67.8	9.4	100%	9%	45%	55%	0%	
All	132	1668	101	109	60.6	65.3	9.4	90%	15%	48%	29%	23%	
U.Sdom.	34	1947	119	127	61.0	65.0	9.2	91%	56%	82%	18%	0%	

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- Horsepower and torque per liter virtually identical
- Similar compression ratio (CR) and % OHC
- U.S. engines had more multi-valve engines and more sophisticated fuel metering