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Wednesday, August 12, 2009 (3:30 – 4:30 pm)
Outline

- History & Motivation
- Review of Feebate Concept
- Overview of UC Research Project
- Focus on “Feebate Analysis Model”
  - (More of a progress report)
- A couple of examples of previous policies
History & Motivation to Address GHGs

2002
California enacts its own law (Pavley) regulating GHG emissions.

2004
Automakers sue California in federal court, claiming Pavley = fuel economy standards, not an emissions regulation.

2006
California passes Global Warming Solutions Act (AB 32). Requires GHG emissions to return to 1990 levels by 2020.
- ~40% of GHGs come from transportation sector
- ~75% of these come from passenger vehicles

If “no Pavley,” requires alternative regulatory options to achieve same reductions.

Relevant “Technologies” [Remark: These are not policies…]
- Improved vehicle technology, alternative fuels, VMT reduction
The Role of California?
More Recent Events (-cont.-)

z April 2007
  y US Supreme Court declares CO_{2} a pollutant under the Clean Air Act and should thus be regulated by the EPA

z December 2007
  y Congress passes the Energy Independence and Security Act
    x Requires fuel economy increase to at least to 35 mpg by 2020
    x => Reduction in CO_{2} emissions of at least 30 percent by 2020.
  y EPA denies California waiver. California and 17 other states file suit.

z September 2008
  y California Air Resources Board solicits the research study on Feebates

z January 2009
  y UC team starts the Feebate Research Project
  y President Obama orders EPA to review decision on California waiver
The Feebate Concept

- A fiscal policy combining
  - A **FEE** on inefficient vehicles
  - A re**BATE** on efficient vehicles.

- (In)efficiency **measure** = Emissions per mile

- A **benchmark (or “pivot point”)**
  - Defines which vehicles get fees / rebates

- A **functional form** determines payment amount
  - Frequently there is a **rate** parameter that can be used to adjust these.

- There are also important options for:
  - **Implementation** strategies
  - **Locus** of monetary transaction
Simplest Feebate

Simplest feebate is linear in GHG emissions per mile. Here, benchmark is origin, rate, $R$, is slope of the line. System is revenue neutral if right benchmark chosen.

$$Feebate = Rate(E_o - E)$$

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A feebate can be viewed as a capitalized tax on future GHG emissions.

\[ PV = \int_{t=0}^{L} C(E_0 - E)M_o e^{-\delta t} e^{-rt} dt \]

Assuming:
- 14,000 miles/year when new
- Decreasing at 4%/year
- Discount rate of 7%/year
- Expected life of 14 years

\[ PV = C(E_0 - E)100,000 \]

\[ PV = \frac{$100}{tCO_2} \left( \frac{1g}{mi} \right) 100,000mi \Rightarrow R = \frac{$10}{g / mi} \]
UC Feebate Research Project: Overview

**Research Purpose**
- The UC Feebate study for the California Air Resources Board will comprehensively support their decision-making about feebates.

**Research Objectives**
- Design and assess feebate policy options from multiple perspectives, and make recommendations (!)
  - Qualitative: Reaction/opinions of stakeholders
  - Administrative: Real-world implementation issues
  - Quantitative: Forecasts of consumer & manufacturer behavior
  - Policy/Other: Interaction with other GHG policies
Task Overview

Task 1 Lessons Learned

Task 2 Focus Groups and Interviews

Task 3 Policy Formulation

Task 4 Feebate Analysis Model

Task 5 Policy Analysis

Task 6 Policy Implications

Task 7 Statewide Survey

All Tasks

Final Project Report

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UC Feebate Research Project: Personnel

z Co-Principal Investigators
  y David S. Bunch, UC Davis
  y David L. Greene, Oak Ridge National Labs

z Berkeley
  y Tim Lipman, Susan Shaheen
  y Walter McManus (University of Michigan)

z Other personnel
  y Chris Knittel (Econ, UC Davis)
  y Yueyue Fan (Civil & Env Eng, UC Davis)
  y David Brownstone (Econ, UC Irvine)
  y Students:
    x Andy Lenz, Changzheng Liu, Amine Mahmassani
Task 4: Feebate Analysis Model Development

**Two-Tiered Modeling Approach**

**Manufacturer Decision Model (MDM)**
- Vehicle offerings characterized at the vehicle configuration level (year/make/model/engine/transmission)
- Given scenario inputs, model their decisions wrt what vehicles to produce and offer for the period 2008-2025
- Primary “decision”: How much to improve fuel economy?
- Aggregate-level national New Vehicle demand model

**California Vehicle Market Simulation Model**
- Uses vehicle offerings from MDM as inputs
- More comprehensive, detailed disaggregate demand model
- More detailed analysis of Feebate policy impacts
  - Includes both used and new vehicles, household segments, etc.
Manufacturer Decision Model

*z Modeling Consumer Demand

- Functional Form: Nested Multinomial Logit
- Multi-level Market Structure (5 levels)
  - Buy versus No Buy ("outside good")
    - IF Buy: Passenger Vehicle versus Cargo Vehicle
      - IF Passenger Vehicle
        - Two-seat/Standard Car/Prestige Car/Standard SUV/Prestige SUV/Minivan
          - [One more level, then Vehicle Configs]
      - IF Cargo Vehicle
        - Cargo Van versus Pickup Truck
          - [One more level, then Vehicle Configs]

- At the penultimate level: 20 Vehicle Classes
- At the bottom level: Over 800 vehicle configurations
Nested Logit Demand Model –cont.-

z Actually: Three separate NMNL models
  y California, “Pavley States”, Rest of United States

z Model is “calibrated” (not estimated) using a “base year”
  y Inputs
    x Researcher assumptions on demand elasticity patterns in the tree
      (equivalently, assumptions on NMNL inclusive value parameters)
    x Aggregate sales data from base year (2007)
  y Output
    x Value for “marginal utility of money” (β)
    x Alternative-specific constants for all vehicle configurations

z Vehicles can be “redesigned”
  y Fuel economy can be improved => a fuel savings benefit to consumer
  y But, fuel economy improvement => tech cost added to vehicle price
  y [See next slide]
Technology Cost Curve

Greenhouse Gas Mitigation Cost Curve:
Canadian Large Domestic Car (EEA, 2005)

$3,500
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$0

Increase in RPE

0% 10% 20% 30% 40%
Percent GHG Reduction

y = 18410x^2 - 292.01x
R^2 = 0.9973
Nested Logit Demand Model –cont.-

- **Consumer utility function** (bottom level)

\[ U_j = A_j + B_{t(j)}G_j \]

where

- \( A_j \) = base year alternative-specific constant for vehicle \( j \)
- \( t(j) \) denotes vehicle class that vehicle \( j \) belongs to
- \( B_{t(j)} \) is a “slope parameter” (behaves like a price coefficient)
- \( G_j \) is a “generalized cost” (i.e., uses dollar units)

Before any redesign, \( G_j = 0 \).

If vehicle emission rate is improved by \( \delta \)

\[ G_j = -\text{RPE}(\delta) + \text{Fuel}_\text{Savings}(\delta) \]

In a Feebate system

\[ G_j = -\text{RPE}(\delta) + \text{Fuel}_\text{Savings}(\delta) + \text{Feebate}(\delta, \text{other stuff}) \]
Manufacturer’s Decision Problem

[Lots of possible versions, but…]

Over “some planning horizon”

\[
\text{Max } \text{Objective}_\text{Function}(\delta)
\]

\[
\delta
\]

Subject to: \textbf{Constraints}

\begin{itemize}
  \item Examples: CAFÉ constraints, Pavley constraints, constraints constructed to implement rules about banking and trading credits
\end{itemize}

Objective function options?

\begin{itemize}
  \item Profit?
  \item Consumer Surplus?
\end{itemize}

[We are using Consumer Surplus via NMNL expressions]
Even MORE Recent Events Affect The Model!

**March 2009**
- NHTSA raised fuel efficiency standards for cars to 30.2 mpg and to 27.3 mpg for minivans, SUV’s and light trucks.

**April 2009**
- EPA confirmed that CO₂ emissions pose a threat to human health and welfare and should be regulated by federal law.

**Tuesday May 19, 2009**
- President Obama sets historic fuel efficiency and emissions standards
  - For the first time, CO₂ emissions placed under federal control
  - Reduction = 900 million metric tons, 30% decrease by 2016
  - (And/or?) 30% reduction in new vehicle fleet fuel economy (35.5 mpg) = most aggressive increase in U.S. history
CAFE Model for Period 2008-2010

[This “moves” the base year to 2010.]

\[
\text{CAFE Model}
\]

\[
\max \sum_{t} (1+r)^{-t} \Delta CS(t) \tag{1}
\]

s.t.

\[
\sum_{i=1}^{N_{m,k,c}} \frac{1}{MPG_i(t)} \leq \sum_{i=1}^{N_{m,k,c}} \frac{1}{MPG^{*}_{k,c}(t)}, \forall k, \forall t, \forall m \in M1 \tag{2}
\]

\[
e_i(t) = 1/ MPG_i(t) \times g2 e \tag{3}
\]

If \( \text{timing} (i, t) = 0 \), \( MPG(i, t) = MPG(i, t-1) \), \( \forall i, t \) \( \tag{4} \)
Emissions Model for Period 2011 to ? [2025?]

\[
\max \sum_i (1+r)^{-t} \Delta CS(t)
\]  

(1)

\[
Credit(t) = \sum_i S_i(t)(e_i(t) - e_i(t)) \text{ total } \text{ sales}(t), \forall t
\]  

(2)

\[
Credit(t) + \sum_{t=5}^{t=1} CC(t, t) - \sum_{t=1}^{t=5} CC(t, t) \geq 0, \forall t
\]  

(3)

\[
\sum_{t=5}^{t=1} CC(t, t) * \sum_{t=1}^{t=5} CC(t, t) = 0
\]  

(4)

\[
CC(t, \tau) \geq 0, \forall t, \tau
\]  

(5)

\[
e_i(t) = 1 / MPG_i(t) * g2e
\]  

(6)

If \( timing(i, t) = 0 \), \( MPG_i(t) = MPG_i(t-1), \forall i \)  

(7)
Implementation and Prototype Case

- Models are implemented in GAMS
- Features of Prototype Model:
  - Feebate Function is Linear
  - Rate factor = $20 per gram CO₂ per mile
  - Benchmark is complicated
    - Uses the new NHTSA Footprint Curves
    - [See next slide]
- Other
  - Vehicles have a fixed redesign cycle
  - “Industry Level” optimization of Consumer Surplus over entire planning period (one optimization)
  - Full model includes: CAFÉ/Emissions Std, Banking and Trading
Feebate benchmarks could be vehicle class-specific or could even be a function of footprint, like the new CAFE footprint standard.
Results: Limited thus far....
Still Much To Do: Alternative Policy Options

- **Functional Forms**
  - Straight Lines versus Step Functions

- **Alternative Benchmarks**
  - One benchmark for all vehicles
  - Two: Passenger cars and Light duty trucks
  - Class based: 11 classes? 14 classes?
  - [Footprint you have seen]

- **Rate factors**: Range from $10 to 30 grams per CO₂ per mile

- **Lots of combinations!**

- **Issues**
  - Revenue neutrality
  - “Surprises”
  - Role of vehicle performance
U.S. Gas Guzzler Tax

= Half a feebate system.
Is a step function rather than a straight line.
R is approx $1,800/0.01gal/mi (= $20/g/mi)

Approximately $1,800 per 0.01 gallons per mile.
France’s bonus/malus feebate

It is also a step function.

\[ R \approx \$16.50 \text{ per g/mi (}\$1,500 \text{ per 0.01 gal/mi)} \]
Recent ‘Lessons Learned’

z France’s bonus/malus system has already had a large effect on vehicle sales.

z Meeting with M. Boccon-Gibod, French Ministry of Finance.

z In 2007:
  y 30% of passenger cars sold in France had emissions rates < 130 g/km.
  y 45% were in the range 130-160 g/km.
  y 25% emitted more than 160 g/km.

z In 2008:
  y 43% emitted < 130 g/km.
  y 42% emitted between 130-160 g/km.
  y 15% emitted more than 160 g/km.
Additional Issues

z Implementation options
  y Immediate implementation
  y 2-year delay
  y Phase-in by increasing slope
  y Phase in by transition from net subsidy to revenue neutrality
  y Phase in by closing “doughnut hole” (next slide)

z “Locus of monetary transaction” options
  y State-to-manufacturer
  y Dealer-to-customer
  y State-to-customer
What is a closing doughnut hole?

$ Feebate$ Feebate

(E-E_0)$

$ Feebate$
Options for Rates

- We* are currently considering a range of $10-$30 per g/mi.

- Replacement of Pavley will require allowing the feebate rate to be determined by the need to reduce emissions.

- Feebate rates higher than a cap-and-trade C price can be justified:
  - Correct market imperfection
  - Reduce oil dependence

*Should not imply any current decisions by CARB.