The Impact of Fuel Economy Regulation in India

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Introduction to the Indian Car Market

- India is one of the two fastest growing car markets in the world
  - 2002: 600,000 new cars
  - 2010: 2,300,000 new cars
- Indian government is pursuing policies to curb fuel consumption
  - Mandatory fuel economy labeling coming soon
  - BEE is preparing mandatory fuel economy standards
- However, government continues to subsidize diesel fuel
  - Diesel fuel 33% cheaper than petrol (41 v. 64 Rs./Liter)
  - Diesel share of new car market growing rapidly - 1/3 of passenger vehicles are diesel

Research Questions and Methods

- Do consumers *undervalue* operating cost savings of higher fuel economy?
  - Commonly cited justification for fuel economy standards (Greene 2010; Alcott and Wozny 2010)
  - Hedonic analysis of new car market (Chugh, Cropper, Narain 2011)
- How do fuel economy standards compare to eliminating diesel subsidy in terms of consumer welfare?
  - Estimate a discrete-continuous model of vehicle choice and kilometers driven using data on new car purchases, 2002-2010
  - Model estimated by FIML following Bento, Goulder, Jacobsen, and von Haefen (2009)

Overview of Hedonic Approach

Estimate marginal cost of fuel economy from hedonic price function. See if present value of fuel savings falls within 95% confidence interval of marginal cost.

- First stage of hedonic model estimated to determine implicit price of fuel economy to consumers (Rosen 1974)
- Instrument for fuel economy as it is likely to be correlated with unobservable car attributes
- Each of four market segments is considered separately (petrol hatchbacks, diesel hatchbacks, petrol sedans, diesel sedans)
- Present value of fuel economy improvement computed over life of car based on average driving distances for each segment

Data

- 2002-2008 vehicle prices (Delhi) and characteristics at the version level from AutoCar India
- 2002-2006 market shares at the model/fuel-type level from SIAM
- Monthly driving distance at the model/fuel-type level from JD Power Asia
- Fuel prices and consumer price index from Indiastat
- Interest rate and vehicle life assumptions from World Bank's Low Carbon Growth Project

Summary Statistics

Vehicle Characteristics (India v. US)

Variables	Petrol hatchback	Diesel hatchback	Petrol sedan	Diesel sedan	US Car
Price (USD 2008)	10000	11900	21500	20800	24100
Kerb weight (Pounds)	1790	2160	2330	2500	3530
Power-to-Weight (Horsepower/Pound)	0.032	0.027	0.041	0.029	0.054
City fuel economy (MPG)	28.4	28.9	22.2	28.8	19.4
Distance driven (Miles/Month)	708	1270	838	1190	1201

Details of Hedonic Approach

- Each new car buyer faces a price function that describes the relation of prices (P) to car characteristics (Z) and fuel economy (kpl)
- Maximizes utility (U) as a function of Z, driving distance (K), and consumption of the outside good (x):

$$U = x + u(Z, K)$$

- If buyer is sufficiently forward looking, he faces the budget constraint:

$$y = x + P(kpl, Z) + K \sum_{t=0}^{T} \frac{1}{(1+r)^t} \frac{p_f(t)}{kpl}$$

Details of Hedonic Approach

- Can we reject the hypothesis that the average consumer is buying the (Z, K, x) bundle that equates marginal price of fuel economy to marginal benefit of reduced operating cost?
- Determine whether present value of operating cost savings falls within 95% confidence interval of implicit price of fuel economy, evaluated at share-weighted average car characteristics and driving distance
- Requires assumptions on T, r, and expectations of future K and p_f
  - baseline scenario: $r = 15\%$, $T_h = 11$, $T_s = 12$, $K(t) = K(0)$, $p_f(t) = p_f(0)$
  - sensitivity to assumptions: $r = 10\%$, $T_h = 20$, $T_s = 20$, $K(t) = K(0)$, $p_f(t) = p_f(0)$
  - ongoing work: include best available information on probability of vehicle survival at each age, driving distance at each age, and expectations of fuel price increases

Specification

- $\ln P(Z_j, kpl_j) = X_j\beta + kpl_j\gamma + \epsilon_j$
- Fuel economy is negatively correlated with desirable attributes (e.g. weight, power)
- If *kpl* improvements are made by sacrificing desirable attributes, and some of these are unobserved, γ will be downward biased
- Instrument for fuel economy of a given petrol hatchback model using average fuel economy of petrol sedans of the same make
- Explore sensitivity to specification based on various combinations of: weight, power to weight ratio, torque, engine size, luxury index, safety index, transmission type, and city fuel economy

Specification

- Base model: fuel economy, weight, transmission, luxury index, safety index, year dummies
- 1: Base model+horsepower-to-weight ratio
- 2: Base model+horsepower-to-weight ratio+engine size
- 3: Base model+torque
- 4: Base model+torque+engine size

Results

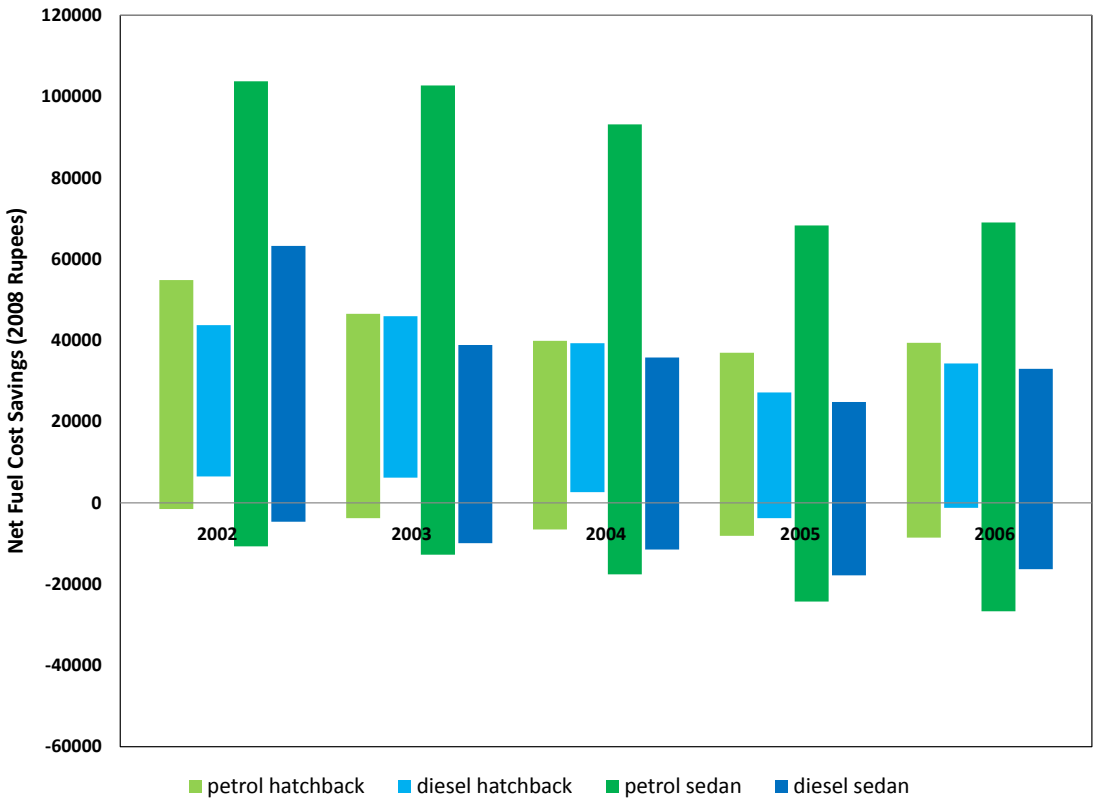
Fuel Economy Coefficients From Various Specifications (OLS v. IV)

		(1)	(2)	(3)	(4)
Petrol hatchback	**OLS**	0.0144**	0.000870	0.0128	0.00381
	IV	0.0316*	0.0155	0.0935***	0.0899***
Diesel hatchback	**OLS**	0.0358***	0.0363***	0.0281**	0.0292***
	IV	0.0734***	0.0873***	0.0633***	0.0830***
Petrol sedan	**OLS**	0.0472***	0.0442***	0.0264**	0.0260**
	IV	0.0484**	0.0597***	0.0699**	0.0843***
Diesel sedan	**OLS**	0.0137	0.0273***	0.00866	0.0239**
	IV	0.0973**	0.0398*	0.103***	0.0447**

*** p<0.01, ** p<0.05, * p<0.1

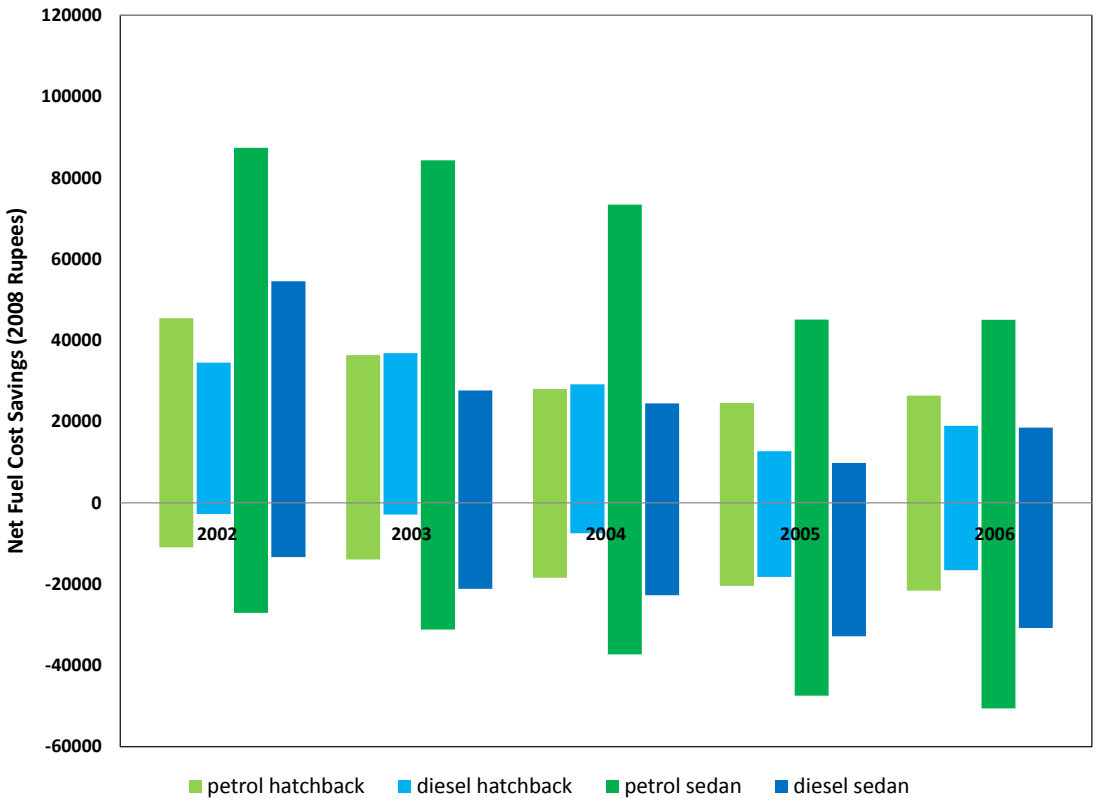
Results

$$r = 15\%,\ T_h = 11,\ T_s = 12$$



Results

$$r = 10\%,\ T_h = 20,\ T_s = 20$$



Discussion

- Commonly cited justification for fuel economy standards does not appear valid in Indian car market
- Mean consumer doesn't undervalue fuel economy in any segment
- Result is robust across a variety of specifications and assumptions

Work In Progress

- How will fuel economy standards affect consumer welfare?
- Would eliminating the diesel subsidy be a cheaper way to achieve the same reduction in fuel consumption from a welfare perspective?
- Estimate a discrete continuous model of vehicle choice and kilometers driven using data on new car purchases, 2002-2010
- Model estimated by FIML following Bento, Goulder, Jacobsen, and von Haefen (2009)
- Calculate expected welfare measures for change in price of diesel and for impact of fuel economy standards under various assumptions about how producers meet standards

Data

- 2002-2010 individual household level responses to JD Power Asia APEAL survey
- Approximately 5,000 annual observations of vehicle choices and monthly driving distances
- Household characteristics: income, age, number of people in household, how many other cars owned
- About 45 models per year, aggregated to the model/fuel-type level
- Car characteristics data come from car magazine AutoCar India

Discrete-Continuous Choice

- Dubin and McFadden (1984) consider the joint choice of the type of water and space heaters and how much to run them
- This approach results in two sets of parameters, one from the discrete choice model and one from the selection-corrected continuous choice model
- Recent applications to cars in US have employed one-step estimators to resolve this issue (Feng, Fullerton, and Gan 2005; Bento, Goulder, Jacobsen, and von Haefen 2009)
- FIML estimation can be employed to model joint decision; random coefficients explicitly model correlation between vehicle choice and driving distance

Discrete-Continuous Choice

- $v_{ij} = -\frac{1}{\beta_{i2}} e^{-\beta_0 - \beta_{i1} X_j - \beta_{i2}(y_i - r_j)} - \frac{1}{\beta_{i3}} e^{\beta_{i3} p_j} + \epsilon_{ij}$
- $\ln(K_{ij}) = \beta_0 + \beta_{i1} X_j + \beta_{i2}(y_i - r_j) + \beta_{i3} p_j + \eta_{ij}$
- With ϵ_{ij} assumed iid extreme value type-I and η_{ij} a normally distributed measurement error
- Probability of a car/K observation is

$$Pr(j, K_{ij}|\bar{\beta}, \sigma, \cdot) = \int Pr(j|\beta_i, \cdot) f(K_{ij}|j, \beta_i, \sigma, \cdot) \phi(\beta_i|\bar{\beta}, W) d\beta$$

- $L = \prod_{i=1}^{N} \prod_{j=1}^{J} Pr(j, K_{ij}|\bar{\beta}, \sigma, \cdot)^{1_{ij}}$
- Currently working on alternate model specifications including vehicle-specific dummies, and measures of expected welfare impact

Scenarios To Be Addressed

- Fuel economy regulation and consumer welfare
  - Short run: simulate new market equilibrium conditional on vehicle characteristics held fixed
  - Medium run: consider possible compliance scenarios based on international experience (reduced weight, power, etc.)
- Compare to welfare impact of removing diesel subsidy
- Also being discussed: increasing tax on diesel cars
  - How does this proposal compare in terms of fuel conservation and consumer welfare?