

Econ 366 – Energy Economics

Fall 2012

Transportation Energy Demand

Transportation Energy Demand

- Two major components: passenger (fuel consumption per passenger mile x passenger miles) and freight (fuel consumption per
- Many modes: car, truck, rail, air
- Several fuels: diesel, gasoline, electricity
- Levels of activity and energy demand are affected by both household and firm decisions.

Demand Responses:

- Short-run: change the number of miles driven (and amount of freight carried) using current vehicle / fleet
- Long-run: also change vehicle(s) and possibly location of firms / households
- Unlike residential demand (based on maximizing utility) and industrial demand (based on profit-maximization or cost minimization), transport demand doesn't fit neatly into standard consumer or firm theories → large variety of *ad hoc* models used

Examples of Types of Models Used

Example 1:

(a) Total Transportation Fuel Demand depends on (i) price, (ii) real per capital GDP, and (iii) previous demand (habit effects);

(b) Market shares of individual fuels depend on own and substitute prices, real per capita GDP, market share from previous year (path dependence, gradual change of vehicle stock)

Changes in the Vehicle Stock: Switching Fuels

- In addition to 'standard' fuels, purchasers may consider:
 - Electric or hybrid cars
 - LNG as an alternative to diesel for trucking
- Distribution system needed for each fuel
 - Already in place for gas, diesel
 - 'chicken-and-egg conundrum' for new fuels
 - <http://www.cbc.ca/news/canada/sudbury/story/2012/09/26/sby-electric-car-charger-stations.html>
 - <http://common-resources.org/2012/advanced-technology-vehicles-the-chicken-and-egg-conundrum/>

Chicken and Egg Conundrum

- Low adoption rates of advanced technology vehicles: alternative fuels (ethanol, natural gas); hybrid and battery electric; fuel cells
- Battery electric cars: high purchase costs → small number sold → difficult to achieve 'economies of scale' (average costs go down as quantity produced falls) → difficult to increase adoption rate →
- Alternative fuels: lack of refuelling stations → less attractive to potential buyers → low customer base for potential refuelling station owners → low return from investing in setting up stations →

Examples of Types of Models Used

Example 2:

(a) Fuel demand (litres) will be a function of the (i) number of cars, (ii) usage (km/year) of these cars, (iii) fuel consumption of cars (km/litre);

(b) Each of these is in turn affected by economic factors:

- car ownership, for example, is expected to depend on income and other factors;

- usage depends on fuel prices and other factors;

- fuel consumption depends on type of vehicle purchased (weight, engine size) and driving habits

Examples of Types of Models Used

Example 3:

Demand for fuel for freight delivery depends on:

- volume of goods to be transported (which in turn depends on the strength of the economy)
- location of firms and end-users of products
- infrastructure and geography (determines which modes are available)
- characteristics of fleet (vehicles, ages, fuel efficiency)

Road Transport Component: Example 3

- For each vehicle type within a fleet:

$$TED_i = Q_i \times D_i \times SP_i$$

TED = total energy demand

Q = quantity of vehicles of type i

D = distance travelled

SP = Specific consumption of vehicle

Road Transport Component: Example 3

- Add up over all vehicles:

$$TED = \Sigma(Q_i \times D_i \times SP_i)$$

Let $S_i = (Q_i / Q)$ where Q is the total fleet size
i.e., S_i is the share of vehicle type i in the fleet

$$\rightarrow TED = Q \Sigma(S_i \times D_i \times SP_i)$$

Road Transport Component: Example 3

$$TED = Q \sum (S_i \times D_i \times SP_i)$$

4 effects: (i) fleet effect

(ii) structural effect (composition of fleet)

(iii) mileage effect

(iv) technical efficiency effect

First 2 primarily influenced by changes in the economy,
last 2 affected by policy and technical change

Elasticities and Rebound Effects in the Transport Sector: VTI Study

- Litman, Todd (2012), “Changing Vehicle Travel Price Sensitivities: The Rebounding Rebound Effect,” Victoria Transport Policy Institute Working Paper
- http://www.vtpi.org/VMT_Elasticities.pdf
- ***Paradox***: lower transportation prices lead to higher transportation costs

Rebounding Rebound VTI Study

- transportation **prices** are the direct payments made by consumers to purchase goods: fuel, parking, road tolls, distance-based insurance premia
- transportation **costs** consist of the resources used to provide goods (including social costs or **externalities***): increased activity → congestion, pollution, accidents
- **externality**: effects of one agent's decision on agents who are not 'voluntary parties' to the decision

Rebounding Rebound VTI Study

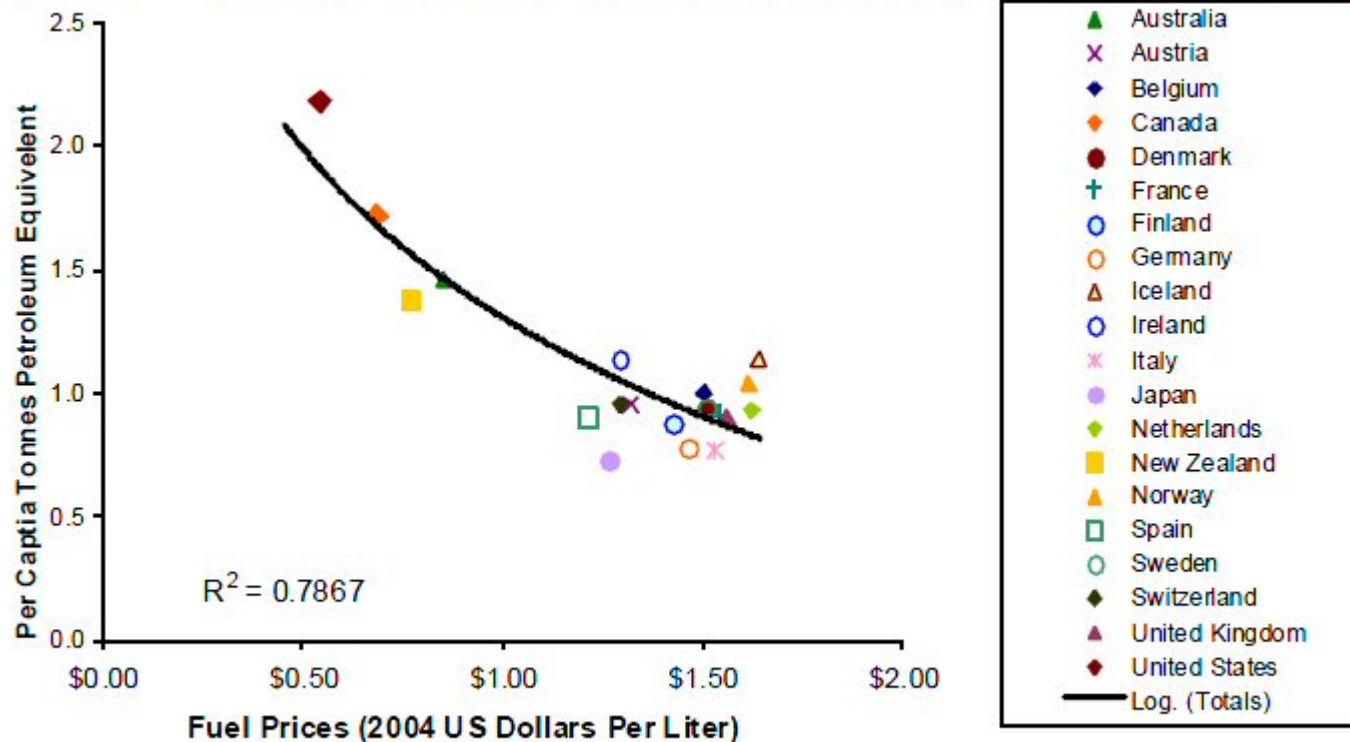
- changes in prices → changes in activity levels
→ changes in fuel demand, pollution,
congestion
- success of price-based policies depend on
how strong the link between changes in prices
and changes in activity levels and/or fuel
demand is

Rebounding Rebound VTI Study

- if vehicle travel is *inelastic*, responses to price changes will be small
- factors that affect elasticities in the transport sector:
 - importance of fuel price in the household's transport budget (many other costs of driving, fuel may be a relatively minor cost);
 - expected duration of price change (temporary?);
 - income (low-income consumers more price responsive);
 - local alternatives (public transit a viable option?);
 - time period considered (short-run vs long-run)

Fuel Consumption and Fuel Price

Figure 1 Fuel Price Versus Per Capita Transport Energy Consumption (OECD 2005)



As fuel prices increase, per capita transportation energy consumption declines.

Elasticity Evidence: VTI Study

- cross-country evidence from OECD countries indicate a strong negative relationship between per capita transportation energy consumption and fuel prices
- many studies of fuel price elasticities:
 - Epsey (1996): SR -0.26, LR -0.58 (for the US);
 - Lipow (2008): SR -0.17, LR -0.4;
 - Glaister and Graham (2002): SR -0.2 to -0.3, LR -0.6 to -0.8;
 - values depend on time period and location considered
 - North American fuel price elasticities declined during the last quarter of the 20th century
 - vehicle travel doesn't fall as much as fuel consumption as more fuel efficient cars are purchased

Elasticity Evidence: VTI Study

- Canadian Evidence: Boilard (2010)

Changing Vehicle Travel Price Sensitivities
Victoria Transport Policy Institute

Table 2 Canadian Fuel Price and Income Elasticities (Boilard 2010)

Approach	Elasticity	1970-1989		1990-2009	
		Short Term	Long Term	Short Term	Long Term
Dynamic Model	Price	-0.093	-0.762	-0.091	-0.256
	Income	0.046	0.377	0.249	0.699
Cointegration Model	Price	-0.193	-0.450	-0.046	-0.085
	Income	0.209	0.428	0.169	0.423

This table summaries short- and long-term fuel price and income elasticities in Canada.

Changing Canadian Elasticities

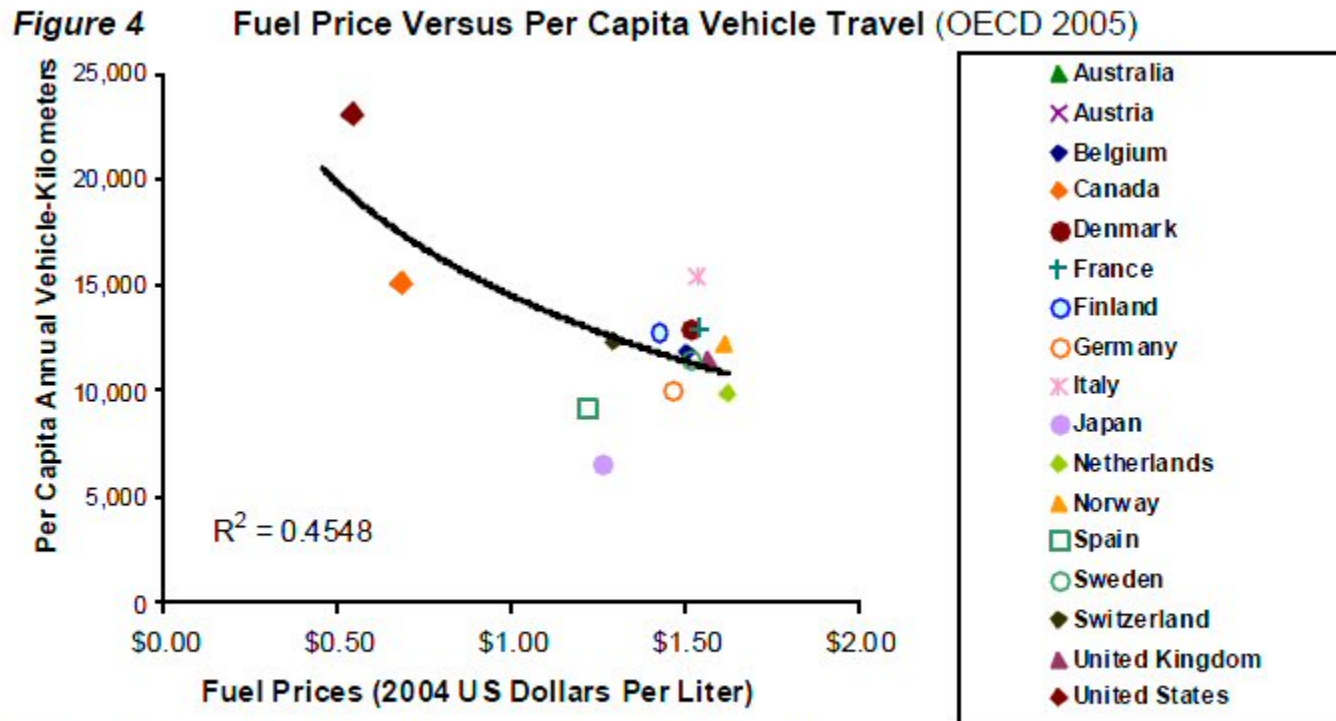
- possible reasons for movements in elasticities:
 - higher per capita vehicle ownership;
 - increased female labour force participation;
 - peak of Baby Boom driving years;
 - real incomes that have grown while real fuel prices have declined (fuel prices a lower share of budgets)
 - highway expansion;
 - urban sprawl

Elasticity Evidence: VTI Study

- Other Empirical Findings
- Li *et al* (2011)
 - fuel tax increases (long-lasting) have a bigger impact than oil price fluctuations (temporary);
 - scope for price-based policies to be effective (?)
- In general, elasticities measured recently (past decade) have been higher than those from previous studies

VTI Study: Fuel Prices and Travel

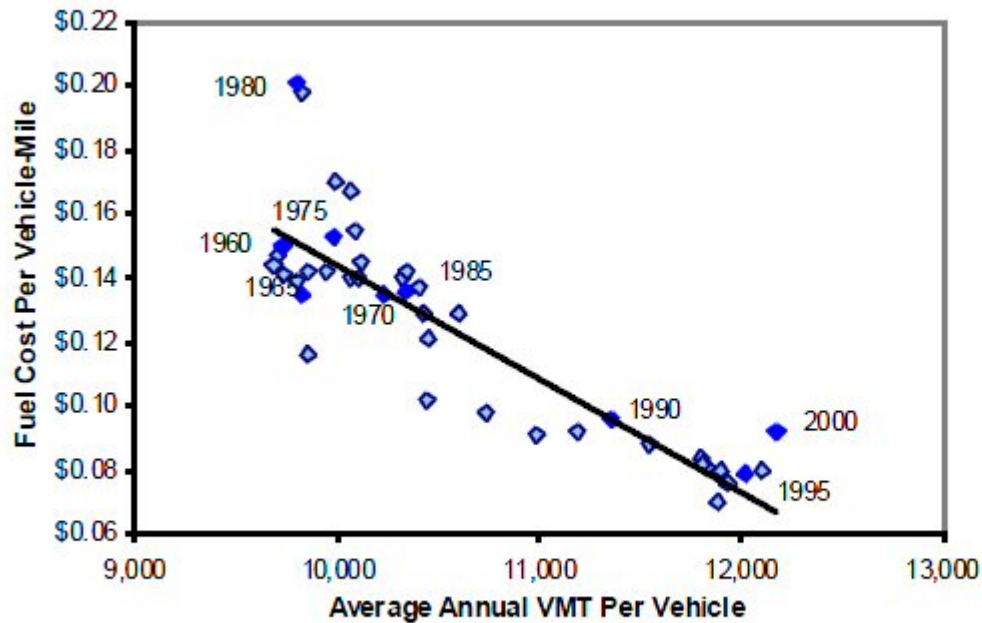
Cross-Sectional Evidence



Higher fuel prices tend to reduce per capita vehicle travel.

VTI Study: Fuel Prices and Travel Time Series Evidence

Figure 5 Fuel Costs Versus Annual Vehicle Mileage (BTS 2001)



Per capita vehicle mileage tends to increase when real (inflation-adjusted) per-mile fuel costs decline.

Travel Elasticity Evidence: VTI Study

- long term elasticity averages around -3
- many studies of travel elasticities:
 - Small and van Dender (2007):
 - values decline with income and over time
 - 1966 to 2001, SR -0.047, LR -0.22;
 - for more recent years, SR -0.026, LR -0.12;
 - Gillingham (2010) based on California odometer readings
 - medium run elasticities of -0.15 to -0.2
 - depends on vehicle type and location
 - multi-vehicle families may respond to price increases by shifting their driving towards their more fuel-efficient cars
 - rural drivers and those using pick-up trucks for work have lower elasticities (fewer alternatives available)

Rebound Effects: VTI Study

- increase in vehicle travel in response to
 - driving a car with better fuel economy and/or
 - availability of less expensive alternative fuels (biofuels, electricity).
- lower costs per mile → can drive more on a given travel budget
- this adds benefits for consumers (as they get utility from the driving)
- this imposes external costs (as the extra driving increases congestion, pollution, risk of accidents)

Factors that could change elasticities and rebounds

- aging population: lower commuting needs, lower incomes
- slower growth of real incomes and rising fuel costs may make fuel a more important portion of the household budget
- improved urban travel options (bike paths, public transit)
- changing preferences (possibly related to health and environmental concerns)

Policy Implications: VTI

Table 5 Pricing Reform Consumer Impacts

Consumer Costs	Consumer Benefits
Incremental user charges (higher prices for roads, parking, fuel, etc.).	Incremental user savings (distance-based insurance and registration fees).
Vehicle travel forgone due to higher prices.	Revenues used to reduce other taxes and fees or provide additional consumer benefits.
Reduced vehicle performance (size, power and speed) due to higher fuel prices.	Reductions in external costs borne by consumers (congestion, accident risk, pollution, etc.).

Pricing reforms can impose costs and provide benefits to consumers. These all should be considered when evaluating a particular price reform.

Policy Implications: VTI

Table 8 Policy Implications Summary

Lower Transport Elasticity Values	Higher Transport Elasticity Values
<p>Price changes cause relatively small changes in fuel consumption and vehicle travel. For example, a 10% fuel price increase only reduces vehicle travel 1-2%.</p>	<p>Price changes cause relatively large changes in fuel consumption and vehicle travel. For example, a 10% fuel price increase reduces vehicle travel 3-6%.</p>
<ul style="list-style-type: none"> • Pricing strategies (higher fuel taxes, road tolls, parking fees, and distance-based insurance and registration fees) are ineffective. They provide relatively little energy savings or emission reductions. • Consumers find it relatively difficult to reduce their vehicle travel and fuel consumption. Higher prices harm consumers and are inequitable. • Rebound effects are small (increased fuel efficiency stimulates little additional vehicle travel), so strategies that increase fuel efficiency (CAFE standards and feebates) provide significant net energy savings and emission reductions. 	<ul style="list-style-type: none"> • Pricing strategies (higher fuel taxes, road tolls, parking fees, and distance-based insurance and registration fees) are relatively effective and beneficial. • Consumers find it relatively easy to reduce their vehicle travel and fuel consumption. Higher prices are not very harmful to consumers or inequitable. • Rebound effects are large (increased fuel efficiency stimulates more vehicle travel), so strategies that increase fuel efficiency provide smaller net energy savings and emission reductions, and exacerbate problems such as congestion, road and parking facility costs, accidents and sprawl.