Econ 366 – Energy Economics

Fall 2012:

Technology Selection and Rebound Effects

Sources

- Sorrell (2009) "The rebound effect: definition and estimation"
- Ryan and Young (2009) "Modelling energy savings and environmental benefits from energy policies and new technologies"
- Both are chapters in Evans and Hunt (eds) International Handbook on the Economics of Energy (Edward Elgar Publishing) available online at:

- http://ualweb.library.ualberta.ca/uhtbin/cgisirsi/x/0/0/57/5?&searchdata1=4895120{001}&user_id=WUAARCHIVE

New Technologies and Energy Demand

- Many government programs target the adoption of energy-saving technologies such as:
    1. Programmable thermostats
    2. High-efficiency HVAC systems
    3. Hybrid vehicles (and fuel-efficient vehicles)
    4. Etc.

New Technologies and Energy Demand

- Does the adoption of these technologies reduce the demand for energy (and therefore reduce the related greenhouse gas emissions)?
  1. Programmable thermostats

  Allow for pre-set changes in temperature for different times of the day. Inexpensive. Easy to use.

  What 'type' of people buy these?

New Technologies and Energy Demand

- Many government programs target the adoption of energy-saving technologies such as:
  2. High-efficiency HVAC systems

  Now less energy is needed to provide the same level of ‘thermal comfort.’ Therefore, it now costs less to run the system.

  Will people still set the same temperatures as when they owned a less energy-efficient system?

New Technologies and Energy Demand

- Many government programs target the adoption of energy-saving technologies such as:

  3. Hybrid vehicles (and fuel-efficient vehicles)

  Less gasoline is required per mile driven. Drivers are making less of a ‘carbon footprint’ per mile driven.

  Will they still drive the same number of kilometres?

Historical Example

- Steam engine

  → big advance in technology

  → less costly to produce goods

  → industrial revolution

  → …….

New Technologies and Rebound Effects

- Cost effective energy-saving technologies are likely to be widely adopted (but often not at the rates that policy makers expect → incentive programs to try to increase uptake)
- Digression on selecting technologies ....

Digression: Selecting Technologies (see Chapter 10 in Hunt and Evans)

- What determines whether or not a household or firm will purchase an energy efficient technology (often as a replacement for an older less efficient technology)?
- “Engineering Approach”: Compare Life Cycle Costs across available technologies

$$LCC_j = (Purchase\ and\ Installation\ Costs)_j + \sum_{t=0}^{T_j} \frac{(Operating\ Costs)_{jt}}{(1 + r)^t}.$$

Life Cycle Costs

- Components

$$LCC_j = (Purchase\ and\ Installation\ Costs)_j + \sum_{t=0}^{T_j} \frac{(Operating\ Costs)_{jt}}{(1+r)^t}.$$

(i) "first cost considerations" (fixed costs): how much does technology j cost to purchase? How much does it cost to install? (money and time costs)

(ii) Present value of "energy use and other day-to-day operating costs" for technology j (variable costs). Note, these generally accrue over several years, and not all years are treated equally (discounting)

What is Discounting?

- When costs or benefits accrue over several periods, economists don't generally treat each period equally
- Most people would prefer to have (or save) $100 now than have (or save) the same $100 "x" years in the future
- Most people would prefer to pay $100 to somebody else "x" years in the future than to pay the same $100 now

See: http://en.wikipedia.org/wiki/Present_value

Discounting

- Most people would prefer to have (or save) \$100 now than have (or save) the same \$100 “t” years in the future

Why? If I have \$100 now, I can invest it at the going interest rate (r) and it will grow to

$100 (1+r)$ after one year

$100 (1+r)^2$ after two years

$100 (1+r)^3$ after three years

....

$100 (1+r)^t$ after t years

Value of a $100 investment
r=0.05

year	Value (dollars)
0	100.00
1	105.00
2	110.25
3	115.76
4	121.55
5	127.63
6	

Discounting

- Discounting (or present value) calculations turn the question around. What is the value today (Y) that is equivalent to X dollars t years in the future? (Formula given in class)

At an interest rate of 5%, $100 three years in the future is equivalent to $86.38 now

Year	Value (dollars)
0	86.38
1	90.70
2	95.23
3	100.00

Back to Life Cycle Costs

- “first costs”: minor for some technologies, substantial for others
- “operating costs”:
  - ***expected*** energy costs (usually ignore rebound effects; i.e., assume the same intensity of use regardless of which technology is purchased)
  - often other costs (periodic maintenance, for example) are ignored in calculations

Back to Life Cycle Costs

- Decision rule: Select the technology with the lowest life cycle costs
- In practice this doesn’t always happen
  - Some people don’t like the light from CFLs
  - Not always easy to search across alternatives (example: furnace breaks down in mid-December)
  - Time costs involved in learning how to use unfamiliar technologies
  - Risk that a new technology may not work as well as advertised or may have much higher repair costs
  - Discount rate may not be the same as the going interest rate (especially for households)
  - Expectations of prices vary across individuals, so do prices (price of electricity in Canada varies across provinces, for example)

Payback Period

- Capital costs are generally higher for more efficient equipment.
  - A programmable thermostat costs more than a manual thermostat
  - An Energy Star ® appliance costs more than a standard model
- These 'incremental' capital costs can be substantial.
- Payback Period = measure of the length of time required for purchaser to recoup the incremental capital costs through energy savings
- As with LCC, usually ignores rebound effects

Back to Sorrell: New Technologies and Rebound Effects

- Cost effective energy-saving technologies are likely to be widely adopted (but often not at the rates that policy makers expect → incentive programs to try to increase uptake)
- Offer energy savings to those who switch to these technologies
- Will, for example, a 20% improvement in fuel efficiency → 20% drop in fuel use?

New Technologies and Rebound Effects

- Micro theory: answer is probably not
- Car: provides transportation services
- Average variable and marginal costs of driving a kilometre are lower for a more fuel efficient car
- Likely to drive more (farther and/or more often): direct rebound effect

Direct Rebound Effects

- Can be decomposed into ***substitution*** and ***income*** effects (car travel and other goods example used in class)
- "price of driving a mile" has gone down resulting in a change in relative prices and, at the old levels of consumption, left over income that can be spent on more driving and/or more other goods
- Due to decreasing marginal utility, rebound effects expected to be smaller for high income households

Indirect Rebounds

- *Embodied Energy*: new equipment (furnace, insulation, vehicle, machine) requires energy to produce and energy to install
- *Secondary Effects* (not all apply in all instances):
  - (a) other goods / services purchased that require energy to produce and transport
  - (b) 'steam engine' effect: technological improvement → improved productivity → increased economic growth

Indirect Rebounds

Secondary Effects (continued):

(c) other goods / services purchased that require energy to produce and transport

(d) Large scale decrease in energy demand from use of new technology → fall in energy prices → increased demand in energy from other types of users

(e) Cost of energy-intensive goods fall more than those of non-intensive goods → people re-allocate budgets towards more (fewer) of the former (latter)

Diagram illustrating direct / indirect effects: transportation

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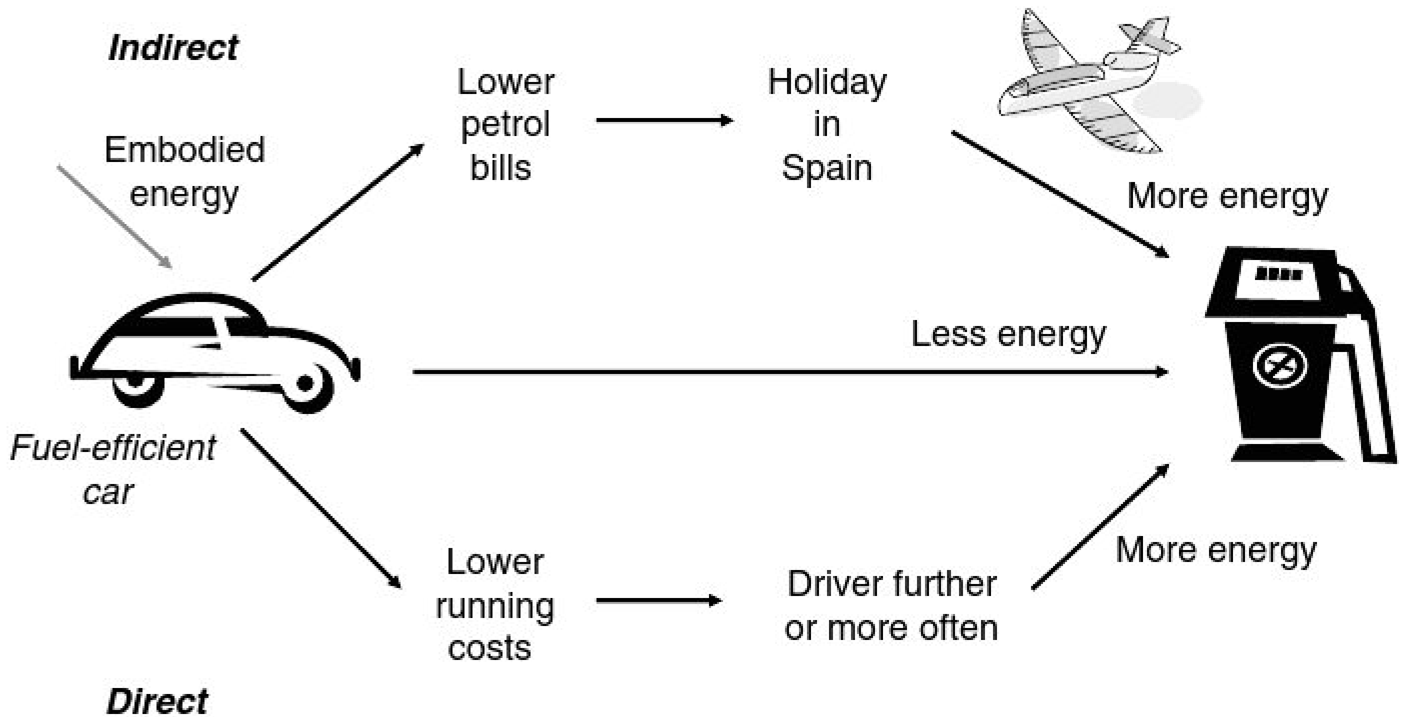


Figure 9.1 Illustration of rebound effects for consumers

Diagram illustrating direct / indirect effects: industrial

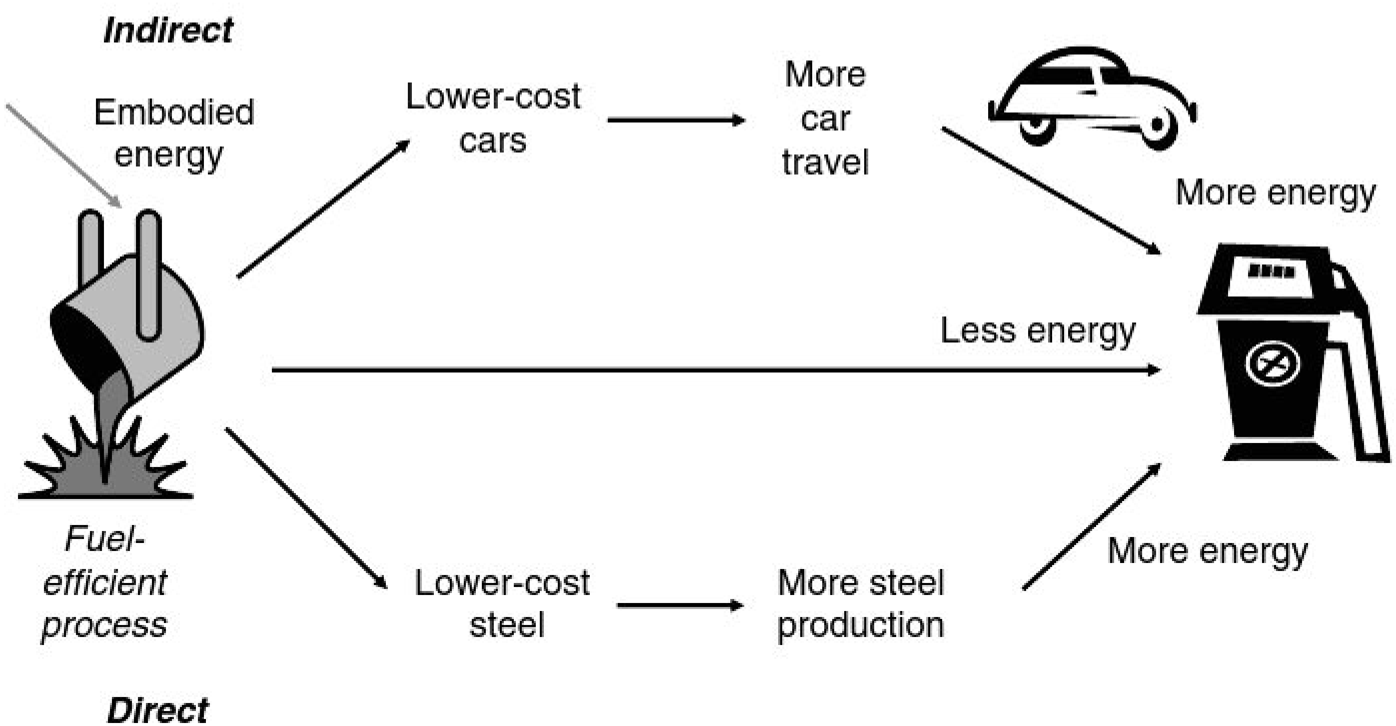
- 

Figure 9.2 Illustration of rebound effects for producers

Overall (Economy-Wide) Rebound

- Sum of all direct and indirect rebound effects
- Usually measured as a percentage
- 50% → one half of potential (according to engineering estimates) energy benefits realized
- 100% → no net benefits realized
- > 100% → backfire

Quote

- “Rebound effects tend to be almost universally ignored in official analyses of the potential energy savings from energy efficiency improvements.” (Sorrell 2009, p. 201).

Sorrell, S. (2009) “The Rebound Effect: Definition and Estimation” in J. Evans and L. Hunt (eds) International Handbook on the Economics of Energy Cheltenham, UK: Edward Elgar, 199-233.

How big are rebound effects?

- Depends on

  (i) how big the substitution effect is

  (ii) how big the income effect is

  (iii) how much energy is embedded in the production and installation of the technology

  (iv) nature and sizes of the set of secondary effects

Practical Issues in Measuring Rebound Effects

- Usually can't do controlled experiments → especially for long-run impacts, many factors may have changed
- Usually don't know what energy consumption would have been in the absence of the new technology (matched pair d-i-d may help)
- Sometimes not clear which way causality runs: *do people change their driving habits because they have a more fuel efficient car?* or *do people buy a more fuel efficient car because they've changed their driving habits?*

Evidence: Direct Rebounds

- Most work has been in household / transportation sector
- Technological improvement → decrease in marginal cost of useful work →

Cars: buy more, buy larger, use less public transit, less car-pooling, buy homes farther away from work and retailers (lifestyle change)

Refrigerators: buy more or keep old one (beer fridge), buy a larger model

Evidence: Direct Rebounds

Washers/ Dryers: change load size, change frequency of use

Heating: change temperature settings, heat larger portion of house

Cooling: change temperature settings, cool larger portion of house, install new AC, replace window system with central system

Estimated Magnitudes

- Range of values from various studies
- Private vehicles:
  - long-run direct rebounds from 10 to 30% → 70+ % of potential benefits realized;
  - short-run as low as 4.5%
  - Rebounds lower for high income individuals

See Transportation Sector Slides for additional results

Estimated Magnitudes

- Household Heating:
  - Direct rebounds as high as 50% relative to engineering estimates
  - Part of this may be due to the limited usefulness of high-efficiency equipment if there are problems with the thermal envelope
  - Rebounds higher for low income households who may have previously settled for poor thermal comfort (lower temperatures, smaller portion of home heated)

Estimated Magnitudes

- Household Cooling:
  - Direct rebounds from 1 to 26%
  - BUT most of these studies are old
  - Not only will those who already had AC change their behaviour, but low cost efficient units have led to a proliferation of AC among those who previously might not have been able to afford this and movement from window to central systems

Estimated Magnitudes

- Washing Machines (Davis, 2007):
  - Laundry accounts for about 10% of US residential energy use
  - 98 households observed before (2 months) and after receiving high efficiency washers (48% less electricity, 40% less water)
  - Demand for clean clothes increased by 5.6%, partially through more loads, mostly heavier loads
  - Time-consuming chores → smaller rebounds? (time costs more significant than energy costs for laundry, vacuuming, etc.)

Indirect Rebounds

- Usually measured through simulation models / economy-wide modelling
- Most secondary effects are long-run; embodied effects more ‘immediate’ (i.e., at time of purchase / installation)
- Total rebound often estimated to be very large, sometimes >100%
- List of studies available in Sorrell Table 9.2