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Direct Rebound Effect Overview

What is the direct rebound effect?

- Increased consumption resulting from cost reductions achieved by efficiency

Much of this material is modified from

Sorrell S & Dimitropoulos J. 2008. The rebound effect: Microeconomic definitions, limitations and extensions. *Ecological Economics*, 65(3), pp.636–649.

Sorrell S, Dimitropoulos J, & Sommerville M. 2009. Empirical estimates of the direct rebound effect: A review. *Energy policy*, 37(4), pp.1356–1371.

Greening LA, Greene DL, & Difiglio C. 2000. Energy efficiency and consumption -- the rebound effect -- a survey. *Energy Policy*, 28(6-7), pp.389-401.

Definitions

Change in Energy Demand = - Change in Efficiency

Technical (engineering) definition of efficiency

$$\frac{\text{Change in Energy Demand}}{\text{Change in Efficiency}} = -100\%$$

$$\frac{\text{Change in Energy Demand}}{\text{Change in Efficiency}} = \text{Rebound} - 100\%$$

Rebound "erodes" some technically feasible savings

Example

$$\frac{\text{Change in Energy Demand}}{\text{Change in Efficiency}} = 30\% - 100\%$$

Change in Energy Demand = 70% x Change in Efficiency

Definitions

$$\frac{\text{Change in Energy Demand}}{\text{Change in Efficiency}} = \text{Rebound} - 100\%$$

$$\frac{\Delta E \,/\, E}{\Delta \varepsilon \,/\, \varepsilon} = \underbrace{\frac{\Delta \text{Work} \,/\, \text{Work}}{\Delta \varepsilon \,/\, \varepsilon}} - 100\%$$

Generally accepted definition for direct rebound

Example

$$\text{Rebound} = \frac{\Delta \text{Work} \,/\, \text{Work}}{\Delta \varepsilon \,/\, \varepsilon} = \frac{\uparrow 10\%}{\uparrow 50\%} = 20\%$$

Measurement: Econometrics

$$\frac{\Delta E / E}{\Delta \varepsilon / \varepsilon} = \frac{\Delta Work / Work}{\Delta \varepsilon / \varepsilon} - 100\%$$

$$\eta_{\varepsilon}(E) = \eta_{\varepsilon}(W) - 100\%$$

$$\eta_{\varepsilon}(E) = \eta_{p}(E) - 100\%$$

Common means of measuring rebound (cross-sectional or longitudinal)

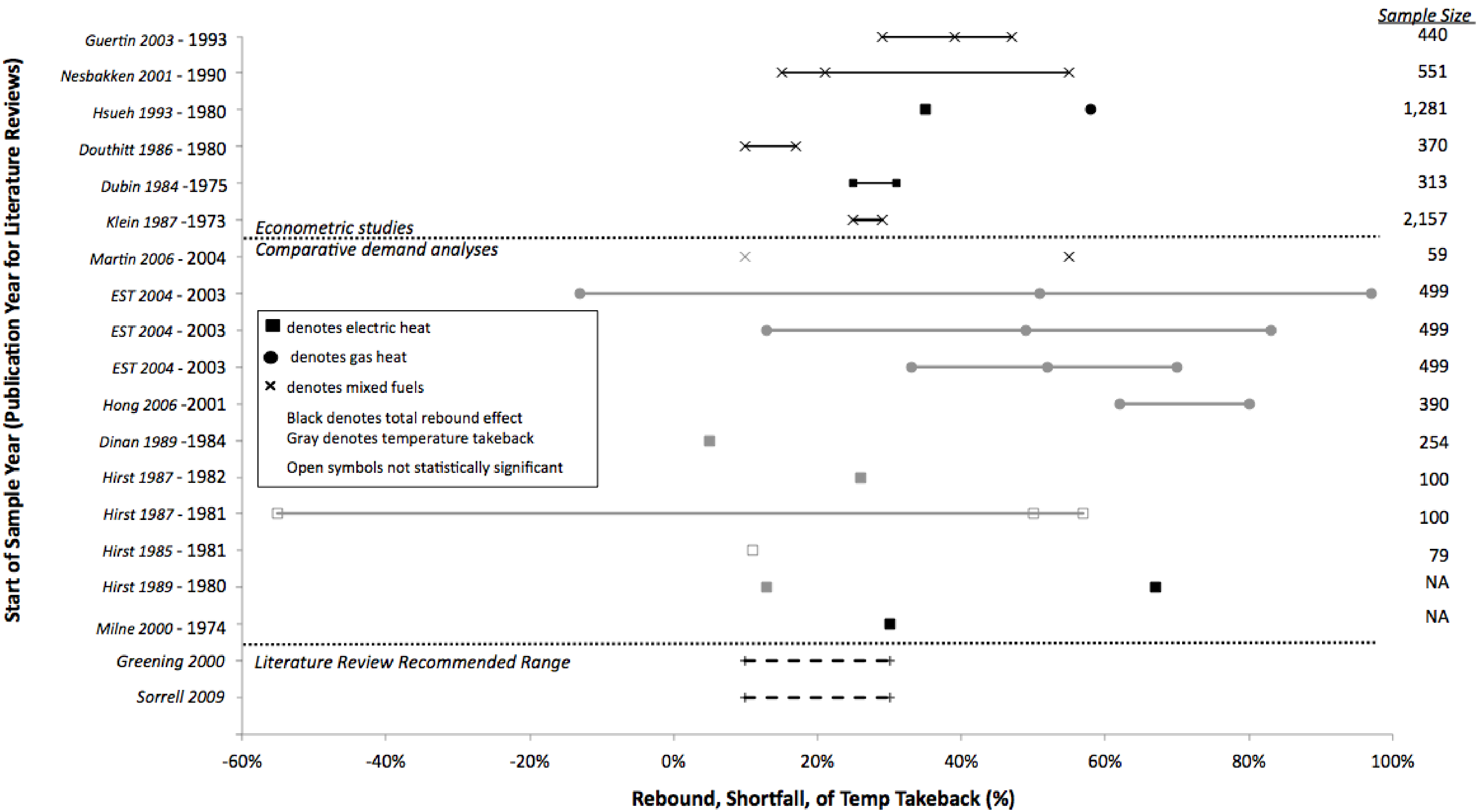
Measurement: Comparative Demand Analysis

- Before / After
- Often issues with
  - Energy use measurement
  - Control group
  - Sample bias
  - Confounding variables
  - Data requirements (sample size/temporal)

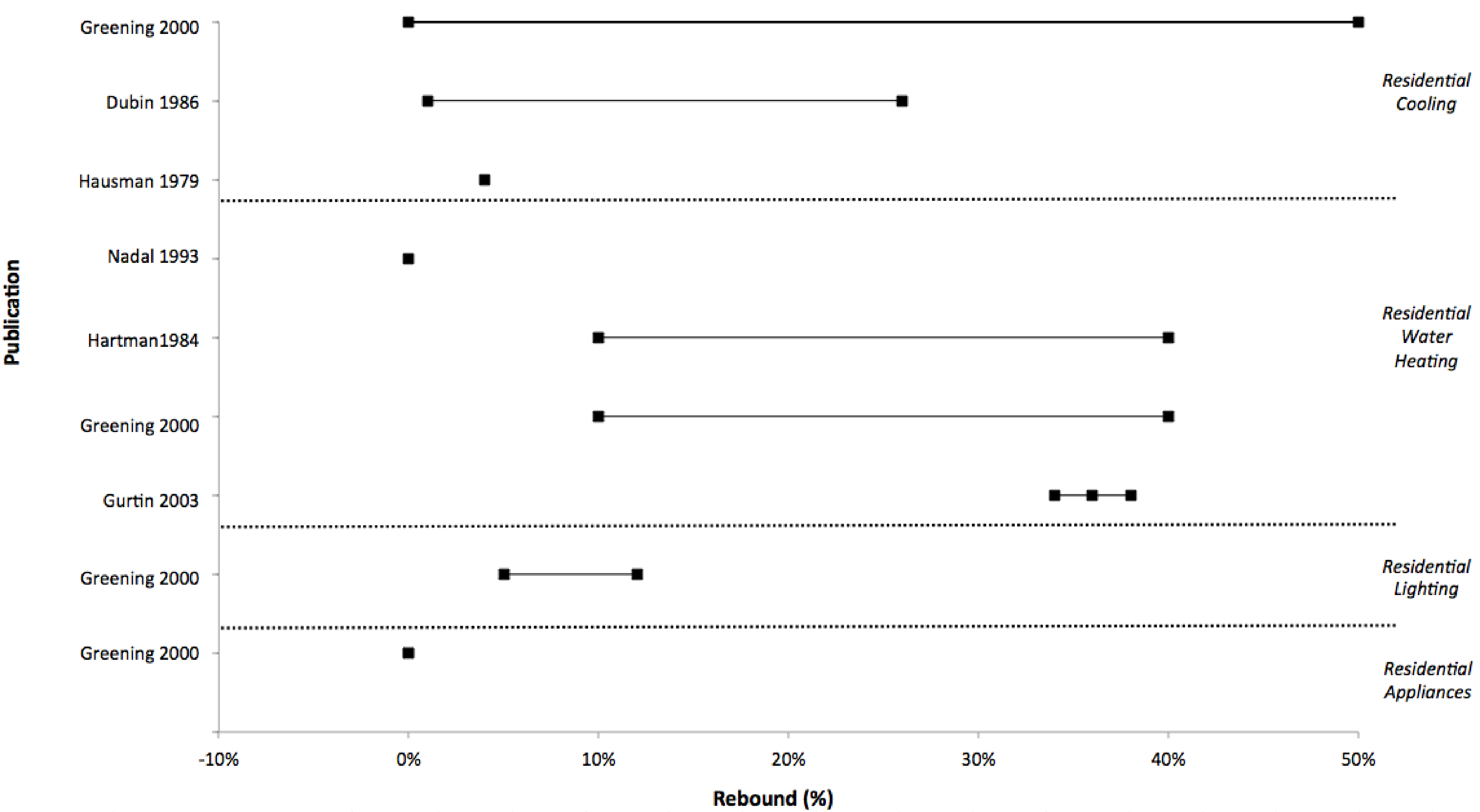
Empirical Estimates

- Majority share of estimates for consumers
  - Household services (mostly heating)
  - Household travel
- Few empirical studies for firms

Empirical Estimates: Household Heating



Empirical Estimates: Other Residential End Uses



Econometric Approach

- Generally preferred by experts
- Limitations to *own price elasticity* model
  - Demand often asymmetric to price changes
  - Generally does not reflect other inputs (capital costs)
  - Does not reflect time preferences
  - User time costs
  - Efficiency not independent of prices, etc (efficiency endogenous)

Definitions from Sorrell (2007)

$$\eta_{\varepsilon}(E) = \eta_{\varepsilon}(W) - 100\%$$

$$\eta_{\varepsilon}(E) = \eta_{\varepsilon}(Num.) + \eta_{\varepsilon}(Capacity) + \eta_{\varepsilon}(Utiliz.) - 100\%$$

$$\eta_{\varepsilon}(E) = -\eta_{P}(W) - 100\%$$

Assume i. price symmetry ii. other inputs (capital) constant iii. price & efficiency are independent

$$\eta_{\varepsilon}(E) = -\eta_{P}(E) - 100\%$$

Hard to get data on useful work (can also be hard to get energy demand data)

$$\eta_{\varepsilon}(E) = -\eta_{P}(S) - \underline{\eta_{K}(W)} \times \underline{\eta_{\varepsilon}(K)} - 100\%$$

Incorporate the effect of capital

Sensitivity of capital costs to efficiency

Sensitivity of work to capital costs

$$\eta_{\varepsilon}(E) = -\eta_{P}(S) - \textit{User Time Trade-Offs} - 100\%$$

Incorporate user-time trade-offs

Research Opportunities

- Define an acceptable, useful definition of direct rebound
  - Prioritize research efforts
  - Address data gaps
- Empirical studies on firms, end uses, and demographics
- Marginal effects (saturation and new markets)
- Define experimental standards

Research Opportunities

- Define roles of empirical methods
  - Econometric – strong theoretical foundation, limited data
  - Comparative demand analysis – “raw” data, hard to separate into theoretical components, what controlling variables matter?
- Short-term, practical guidance for program administrators (role for expert elicitation?)
- Role of advanced metering in managing direct rebound
- Influence of carbon market (price signals) on rebound

Questions / Comments

Definitions from Sorrell (2007)

$$\eta_{\varepsilon}(E) = \eta_{\varepsilon}(W) - 100\%$$

$$\eta_{\varepsilon}(E) = \eta_{\varepsilon}(Num.) + \eta_{\varepsilon}(Capacity) + \eta_{\varepsilon}(Utiliz.) - 100\%$$

Assume i. price symmetry ii. other inputs (capital) constant iii. price & efficiency are independent

$$\eta_{\varepsilon}(E) = -\eta_{P}(W) - 100\%$$

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Incorporate the effect of capital

$$\eta_{\varepsilon}(E) = -\eta_{P}(S) - \underline{\eta_{K}(W)} \times \underline{\eta_{\varepsilon}(K)} - 100\%$$

Sensitivity of capital costs to efficiency

Sensitivity of work to capital costs

$$\eta_{\varepsilon}(E) = -\eta_{P}(S \text{ or } E) - \eta_{P}^{T}(S \text{ or } E) \times \eta_{\theta}(P) \times \eta_{\varepsilon}(\theta) - 100\%$$