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CANADIAN Building Energy End-Use DATA AND ANALYSIS CENTRE
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3rd International Workshop on Empirical Methods in Energy Economics (EMEE2010)

Surrey Energy Economics Centre (SEEC)

University of Surrey, UK

24th – 25th June 2010

NOTE:

The following Presentation represents *Work in Progress* for discussion at the EMEE2010 workshop. It therefore must not be referred to without the consent of the author(s).

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US Residential Energy Demand and Energy Efficiency: A Stochastic Demand Frontier Approach

EMEE2010 workshop at the University of Surrey

Massimo Filippini and Lester Hunt

Motivation and Goals

- All countries are implementing energy efficiency policies
- Similarly, all US states are implementing energy efficiency policies although with different approaches
- The promotion of energy efficiency policy is also a very important activity of the IEA (International Energy Agency) and of the EIA (Energy Information Agency)
- **How to measure the level of energy efficiency?**
- **Energy intensity? Energy consumption/GDP ?**

Strengths and Limitations of the Energy-Intensity Indicators

http://www.eia.doe.gov/emeu/efficiency/ee_ch3.htm

- .."Four energy-intensity indicators were presented in this chapter that may be used as the basis for the measurement of energy efficiency. All four indicators are imperfect…."…..
- …"No single energy-intensity indicator for the residential sector stands out as clearly superior to the others. The choice of indicator depends on the questions asked and on data and resource availability…."

Box 3.2

Energy-Intensity Indicators for the Residential Sector

Million Btu per Building
Million Btu per Household
Thousand Btu per Square Foot
Million Btu per Household Member

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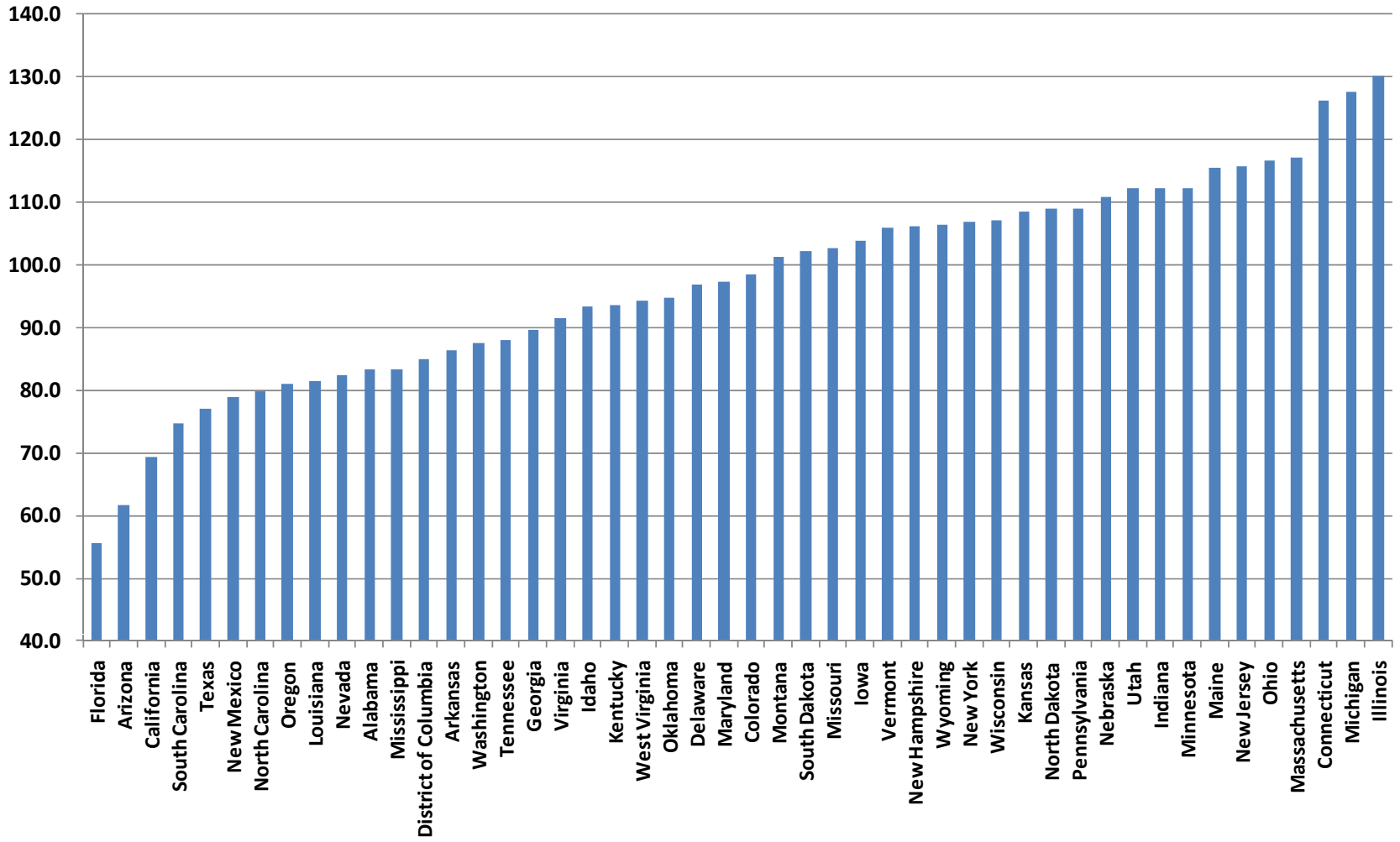
Energy Intensity 2 (Energy per building, Million BTU, 1995-2007)



Goals of the paper

- To estimate the residential level of energy efficiency for US states using an alternative approach based on two branches of the literature:

↳ frontier estimation and

↳ energy demand modelling.

- **An aggregate residential energy demand frontier function is estimated**

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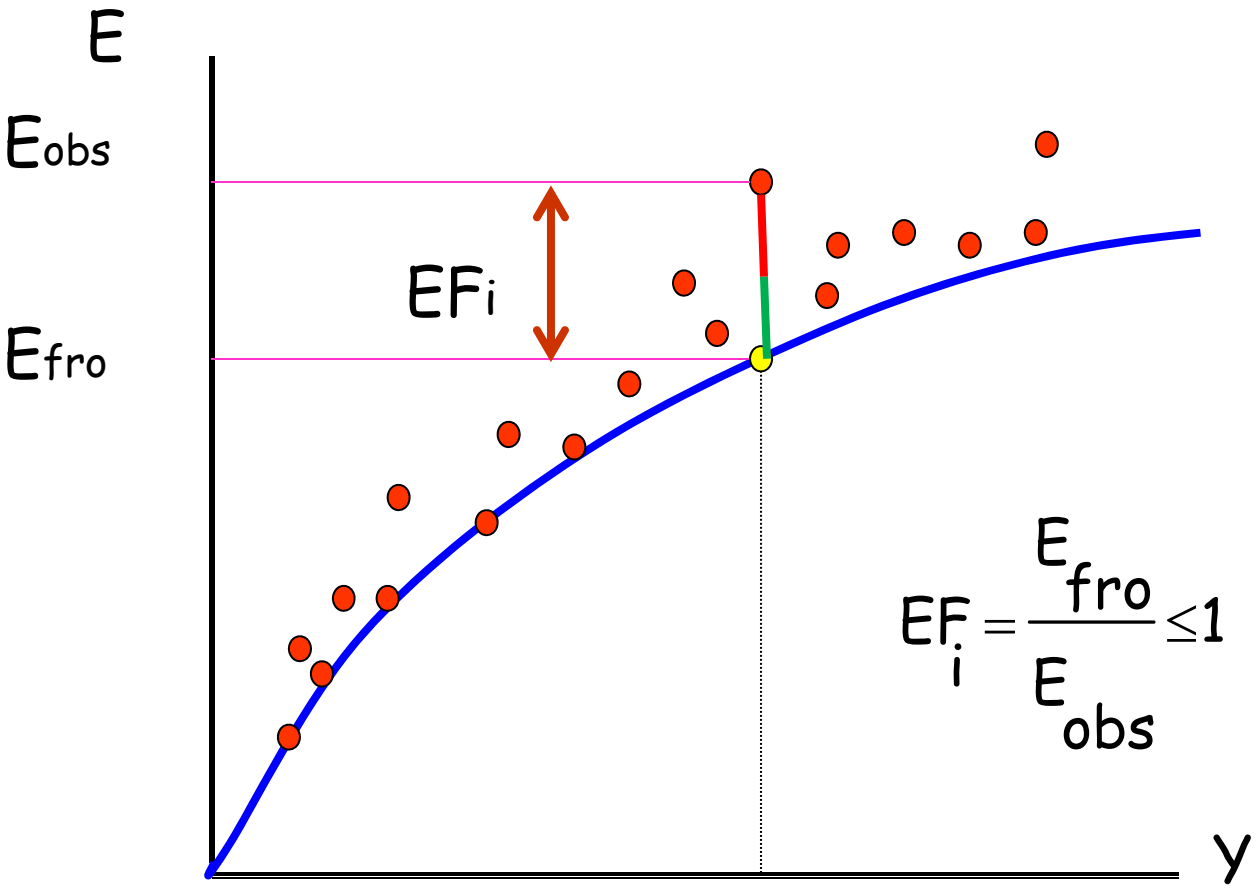
An aggregate frontier energy demand model



$$EF_i = \frac{E_{fro}}{E_{obs}} \leq 1$$

Energy efficiency measures the ability of a country to minimize the energy consumption, given a level of y

Panel data stochastic frontier models

POOLED MODELL (Aigner, Lovell and Schmidt, 1977)

$$\ln C_{it} = \ln C(y_{it}, w_{it}) + u_{it} + v_{it} \qquad u_{it} \geq 0$$

RANDOM EFFECTS MODELL (PITT & LEE, 1981)

$$\ln C_{it} = \ln C(y_{it}, w_{it}) + \alpha_i + v_{it} \qquad \alpha_i \geq 0$$

TRUE RANDOM EFFECTS MODELL (GREENE, 2005)

$$\ln C_{it} = \ln C(y_{it}, w_{it}) + \alpha_i + u_{it} + v_{it} \qquad u_{it} \geq 0$$

Model specification

$$e_{it} = \alpha + \alpha^{y} y_{it} + \alpha^{p} p_{it} + \alpha^{hs} hs_{it} + \alpha^{hdd} hdd_{it} + \alpha^{cdd} cdd_{it}$$
$$+ \alpha^{sh} sht + \alpha^{DR1} DR1_{it} + \alpha^{DR2} DR2_{it} + \alpha^{DR3} DR3_{it}$$
$$\alpha^{DT} DT_{t} + u_{it} + v_{it}$$

- E_{it} : residential energy consumption per capita
- P_{it} : the real price of residential energy
- Y_{it} : Income per capita
- Hs_{it} : Household size
- CDD_{it}, HDD_{it} : cooling and heating degree days
- DC_{it} : share of detached houses
- DRi : *regional dummies* (West, Midwest, Northeast and South)
- Dt : *time dummies*
- u_{it} : energy efficiency assumed to be half-normal distributed

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Data

- Balanced Panel data set
  - 48 US states (i = 1, …, 48)
  - 1995 to 2007 (t = 1995-2007)
- where:
  - E = per capita residential energy consumption in Btu (British Thermal Units)
  - Y = real per capita income (thousand US 2000);
  - P = real price of energy $ per million of BTU (2000=100);
  - Data sources:

eia U.S. Energy Information Administration Independent Statistics and Analysis

BEA BUREAU OF ECONOMIC ANALYSIS U.S. DEPARTMENT OF COMMERCE

NOAA Satellite and Information Service National Environmental Satellite, Data, and Information Service (NESDIS)

	Estimated Underlying Energy Efficiency (Pooled Model)		*Energy Intensity 1 (Energy per capita)*		*Energy Intensity 2 (Energy per building)*	
	Level	*Rank*	*Level*	*Rank*	*Level*	*Rank*
California	0.974	1	25.162	1	69.252	3
Florida	0.946	29	25.656	2	55.649	1
Iowa	0.973	2	44.219	28	103.778	29
Massachusetts	0.917	41	48.428	41	116.997	45

Average correlation coefficients

- Energy Intensity I and Energy Intensity II : **0.90**
- Energy Efficiency and Energy Intensity I (per person consumption): **-0.65**
- Energy Efficiency and Energy Intensity II (per building): **-0.61**

Spearman rank correlation coefficients

- Energy Intensity I and Energy Intensity II : **0.93**
- Energy Efficiency and Energy Intensity I (per person consumption): **0.21**
- Energy Efficiency and Energy Intensity II (per building): **0.22**

Conclusions (1)

- This research is a fresh attempt to isolate core energy efficiency for a panel of 48 US states, opposed to relying on energy intensity indicators
- By estimating a measure of 'underlying energy efficiency' by combining the approaches taken in energy demand modelling and frontier analysis

Conclusions (2)

- The estimates for core energy efficiency using this approach show that although for a number of states the change in energy intensity over time might give a reasonable indication of efficiency improvements; this is not always the case
- It is argued therefore that this analysis should be undertaken to avoid potentially misleading advice to policy makers
- So that looking at relative energy intensity across states might give a misleading picture, unless the influences discussed above are controlled for first