cepe
Centre for Energy Policy and Economics
Swiss Federal Institute of Technology Zurich

CANADIAN Building Energy End-Use DATA AND ANALYSIS CENTRE
CBEEDAC
commercial • residential • institutional

SEEC
Surrey Energy Economics Centre

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).

Sponsored by:

bp

BIEE
British Institute of Energy Economics

Department of Economics
UNIVERSITY OF SURREY

Energy Use in Multi-Family Dwellings

Lucie Maruejols (CBEEDAC) and Denise Young (Department of Economics, CBEEDAC)

EMEE2010
University of Surrey
June 2010

CBEEDAC
CANADIAN Building Energy End-Use DATA AND ANALYSIS CENTRE
commercial • residential • institutional

Department of Economics, University of Alberta
8-14 Tory Building, Edmonton, Alberta T6G 2H4
P. (780) 492-4134 F. (780) 492-3300

Outline of presentation

- Background information
- Overview of agency and information issues
- Data highlights
- Preliminary econometric results

Background Info

- ~43% of Canadian households lived in multi-family dwellings (apartments, row housing, semi-detached houses) in 2006
- These types of dwellings are under-represented in terms of participation in programs such as EnerGuide for Housing (EGH); similar situation in the US
- Limited availability of data regarding energy use and appliance choice in these types of dwellings .... SHEU 2003 sample includes multi-family dwellings (semi-detached, row housing, low-rise apartments)

Energy Efficiency Issues

- Factors unique to this sector:
  - agency issues for the rental sub-sector (Munley et al 1990, Levinson and Nieman 2004)

	Tenant chooses equipment	Landlord chooses equipment
Tenant pays the bill	no principal-agent problem	efficiency problem
Landlord pays the bill	usage and efficiency problem	usage problem

Source: American Council for an Energy-Efficient Economy (2007)

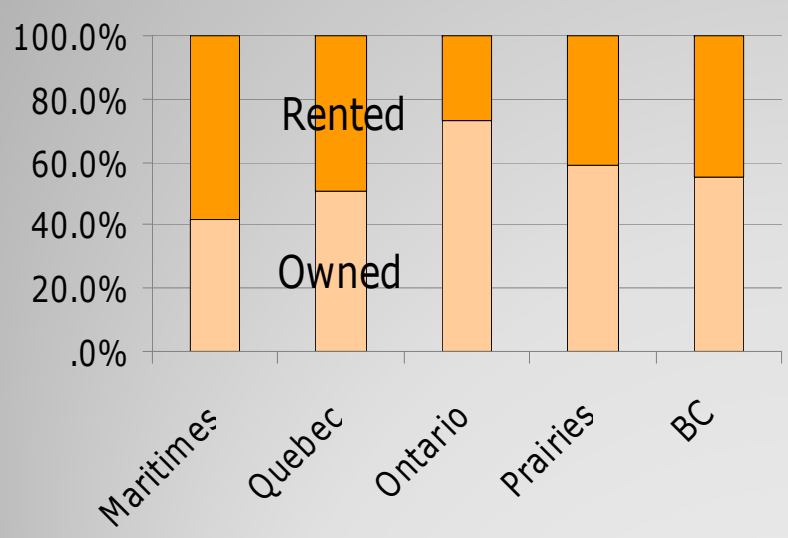
  - information issues: tenants may not be sure of the energy efficiency characteristics of a rental unit (Meyer-Rencshhausen 1983, Levinson and Nieman 2004, Murtishaw and Sathaye 2007)

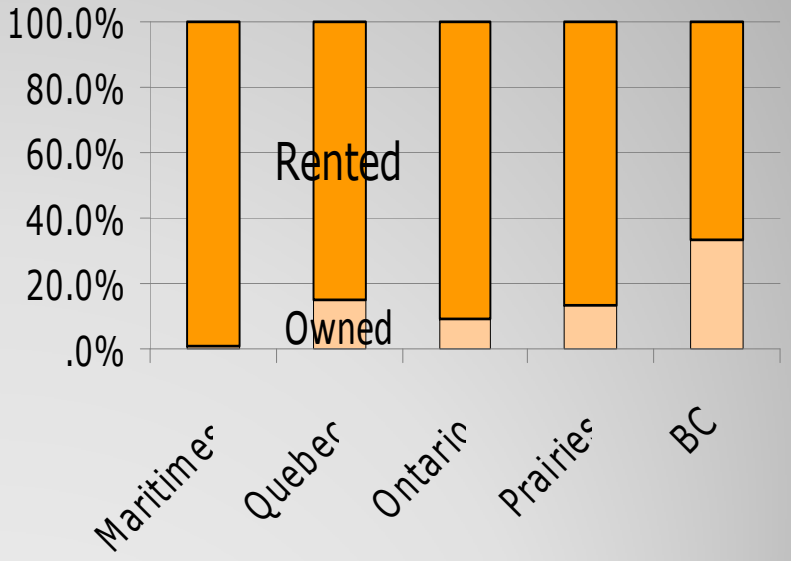
- Multi-family dwellings in SHEU: ownership
- Who pays the bill in rental units?
- Energy Use
- Appliance characteristics
- Temperature settings
- Environmentally ‘unfriendly’ behaviour
- Building renovations

Examination of SHEU Data

- Owners and renters in SHEU 2003

semi-detached / row	low-rise apartments

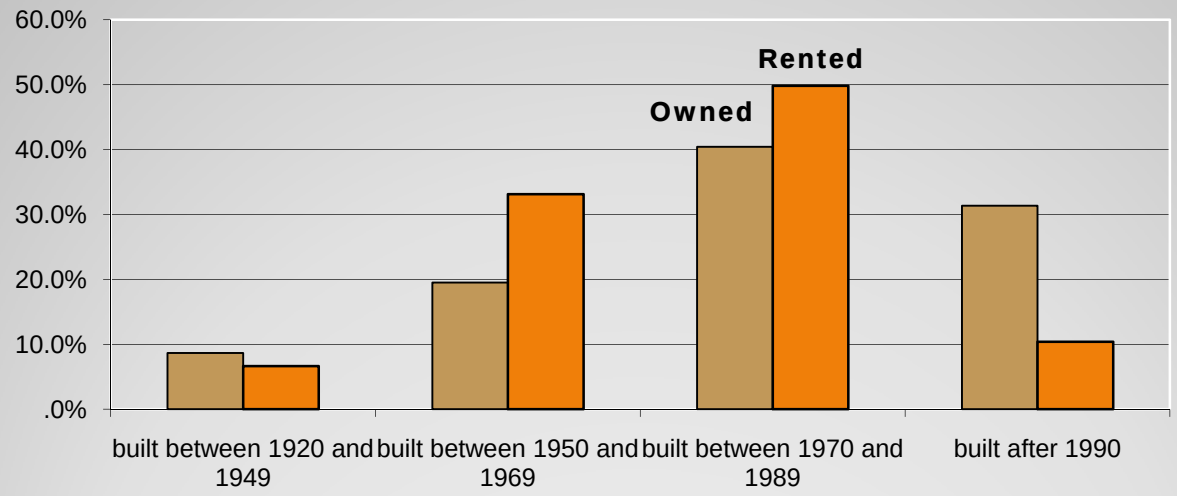




Some summary stats (1)

Some summary stats (2)

- Counihan and Nemtzow (1983): rented buildings tend to be older and less energy efficient → more important to focus on rental sector (?)
- SHEU 2003:



energy source	Semi-detached / row housing		Low-rise apartment		Total	
	Occupant pays	Landlord pays	Occupant pays	Landlord pays	Occupant pays	Landlord pays
Electricity	81%	19%	74%	26%	76%	24%
Natural gas	61%	39%	4%	96%	24%	76%
Oil	33%	67%	6%	94%	12%	88%
purpose						
Heat	73%	27%	55%	45%	60%	40%
Hot water	75%	25%	63%	37%	66%	34%

Who pays the bill? (rental units)

Energy usage in owned and rented dwellings

energy source	Semi-detached / row housing			Low-rise apartments		
	Owned	Occupant pays	Landlord pays	Owned	Occupant pays	Landlord pays
Electricity	0.0297	0.0346	0.0484	0.0403	0.0423	0.0716
Natural gas	0.0313	0.0646	0.0879	0.0407	0.1291	0.1171
Oil	0.0050	0.0629	0.0456	0.0048	0.2516	0.2268
Total	0.0660	0.0635	0.0871	0.0857	0.0694	0.1483

Gigajoules per square foot of heated dwelling area.

equipment	Semi-detached / row housing			Low-rise apartments		
	Owned	Occupant pays	Landlord pays	Owned	Occupant pays	Landlord pays
Heating System	12.6	16.7	19.5	12.6	16.2	15.6
Hot Water Tank	4.4	8.0	8.8	3.8	7.9	6.8
Refrigerator	6	6.2	8.2	6.6	7.8	10.9
Stove	6.4	9.2	11.1	8.6	10.0	13.2
Based on midpoint for cases where age was recorded by category.						

Appliance age in owned and rented dwellings

Appliance type	Semi-detached / row housing		Low-rise apartment	
	Occupant pays	Landlord pays	Occupant pays	Landlord pays
Total	1.10	0.55	0.72	0.43
Housework-related	0.34	0.16	0.27	0.09
Heating / Cooling	0.12	0.01	0.00	0.00
Entertainment	0.64	0.39	0.45	0.34
Number of small appliances per adult				
	3.66	3.06	3.33	3.11

(EnergyStar®) Appliances in rental units

Degrees celsius: heating season	**Semi-detached / row housing**		**Low-rise apartment**	
	Occupant pays	Landlord pays	Occupant pays	Landlord pays
Day	19.65	21.05	19.36	20.44
Evening	20.23	21.11	19.97	20.76
Night	18.97	20.47	18.95	19.74
Share of households where				
Temperature settings change	14.6%	3.0%	7.7%	7.5%
Thermostat programmed	8.4%	2.3%	5.2%	4.0%

Temperature settings in rental units

Behaviour	Semi-detached / row housing		Low-rise apartment	
	Occupant pays	Landlord pays	Occupant pays	Landlord pays
Rinse dishes before dishwasher	52%	83%	77%	79%
Do not use water-saving showerhead	53%	47%	63%	60%
Use hot or warm water in washing machine	47%	77%	35%	66%
Use heat to dry dishes in dishwasher	49%	92%	48%	50%
Use only incandescent bulbs	35%	36%	38%	42%

Environmentally-unfriendly behaviour in rental units

	Semi-detached / row housing		Low-rise apartment	
Renovation type	Owned	Rented	Owned	Rented
insulation of roof or attic	2.17%	0.00%		
insulation of basement or crawl space walls	2.64%	2.00%	5.02%	1.24%
insulation of any exterior walls	2.42%	1.89%	3.95%	0.84%
foundation	0.98%	0.77%	0.94%	0.19%
heating equipment	4.30%	1.86%		
ventilation or AC equipment	2.73%	0.28%		
At least one improvement	11.54%	9.80%		

Building renovations in owned vs rental dwellings: 2003

	Semi-detached / row housing		Low-rise apartment	
Renovation type	Occupant pays	Landlord pays	Occupant pays	Landlord pays
By agent paying electricity (only includes cases that 'match' with theory .....)				
roof	5.01%	9.52%		
exterior wall siding			3.08%	4.31%
ventilation or AC	0.00%	1.03%		
By agent paying heating bill(selected cases that 'match' with theory .....*)				
roof	6.03%	7.49%		
ventilation or AC	0.00%	1.44%	1.78%	3.44%
* For low-rise appliances, additional cases that match with theory include: exterior wall siding, insulation of roof or attic, insulation of basement or crawl space walls, foundation, and heating equipment				

Building renovations in rental dwellings: 2003

Econometric Analysis

- Many possible avenues for econometric modeling:
  - Energy use: many observations are imputed; selection issues when looking at subsets of data (own/rent a function of household characteristics? Correlated with energy use?)
  - Temperature settings (most, but not all, renters control heat settings)
  - Technology Choice: Energy star product use – not well-established in 2003
  - household 'energy friendly behaviour' probit equations
  - renovation probits

- Models of electricity and energy use per square foot of heated area
  - Controls: electricity price (impacts allowed to vary depending on who pays), building characteristics, appliances and appliance characteristics, income, household size, heating/hot water technology, etc.
  - Landlord pays electricity matters for electricity but not for overall energy use
  - Landlord pays heat matters for overall energy use but not for electricity
  - Lower overall energy use in owner-occupied dwellings
  - electricity price coefficient always positive; often significant

Preliminary results: energy use

Preliminary results: temperature settings

- Models of day, evening, and night temperature setting choices
- slightly smaller sample size -- 39 rental units do not have individual heat controls
  - Landlord pays heat → higher temperature settings;
  - Landlord pays electricity → no impact
  - Income, building age, location also matter
  - Thermostat programming matters for day and night temperature settings
  - Households with children tend to keep dwellings warmer at night
  - Higher temperature settings in colder regions

- If landlord pays for energy, expect to see a higher proportion of inefficient small portable appliances (purchased by tenants).
- If tenant pays for energy, expect to see a higher proportion of inefficient major appliances (purchased by landlord)
- Efficiency gauged by whether or not an appliance is labeled as EnergyStar® (but only in effect for 4 years at time of survey)
- No evidence from these regressions that fits with theory

Preliminary results: appliance choice

- Series of probits for whether or not temperature settings change*; rinse dishes before using dishwasher; dry dishes using 'heat' *; no water-saving showerhead; wash clothing not using cold water
- Landlord pays dummies never significant
- Small sample size for dishwasher probits (N=148)
- * outperforms 'naïve model' in terms of predictions

Preliminary results: environmentally unfriendly behaviours

Preliminary results: renovations

- Models for actual 2003 renovations and 2004 planned renovations.
- Probits: 1 if actual (planned) renovation would potentially improve energy efficiency
- "Landlord pays the heat" → prob(planned renovation) increases by 0.16 for the rental dwelling subset; outperforms naïve model; overall model significance p-value is 0.13.

General Findings

- Energy use: owners most efficient, renters who don't pay utilities least efficient. (artifact of imputed data?)
- Temperature regressions consistent with predictions from theory
- Evidence pertaining to other aspects of behaviour tends to not find that who pays the bill matters →
  - All have 'bought into' energy conservation campaigns and have learned to limit use even if marginal cost is zero

OR

  - Households who pay their own bills are not sensitive to bearing a positive marginal cost and adopt similar behaviours to those who do not pay directly

Fin / The End

That’s all folks!