The Influence of Rebate Programs on the Demand for Water Heaters :The Case of New South Wales

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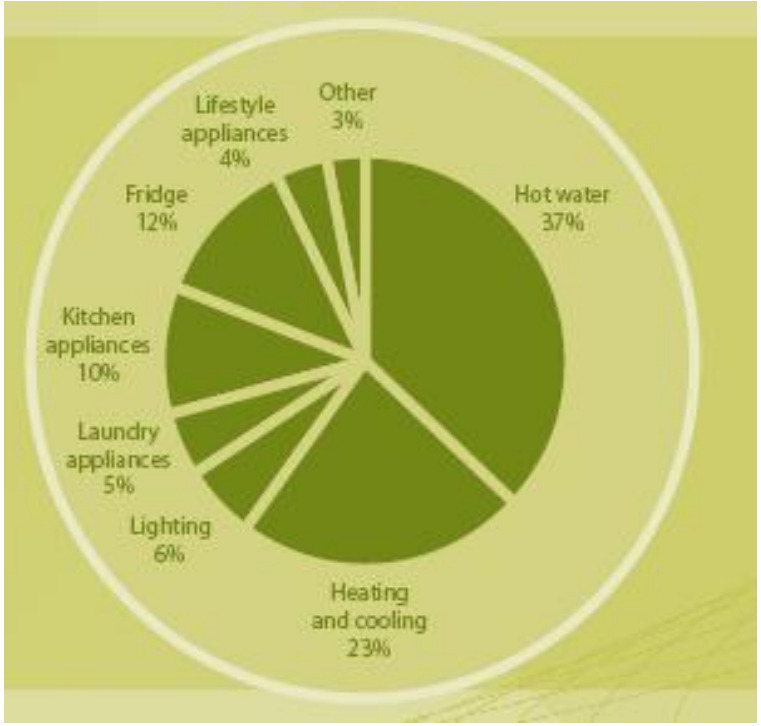
Background

- Australia has high per capita greenhouse gas emissions
  Key driving factor: high emission intensity of energy use.

- Various programs from Federal and state governments to promote energy efficiency improvement

- Focuses on the hot water system rebate programs
  targeted at New South Wales (NSW) residential sector

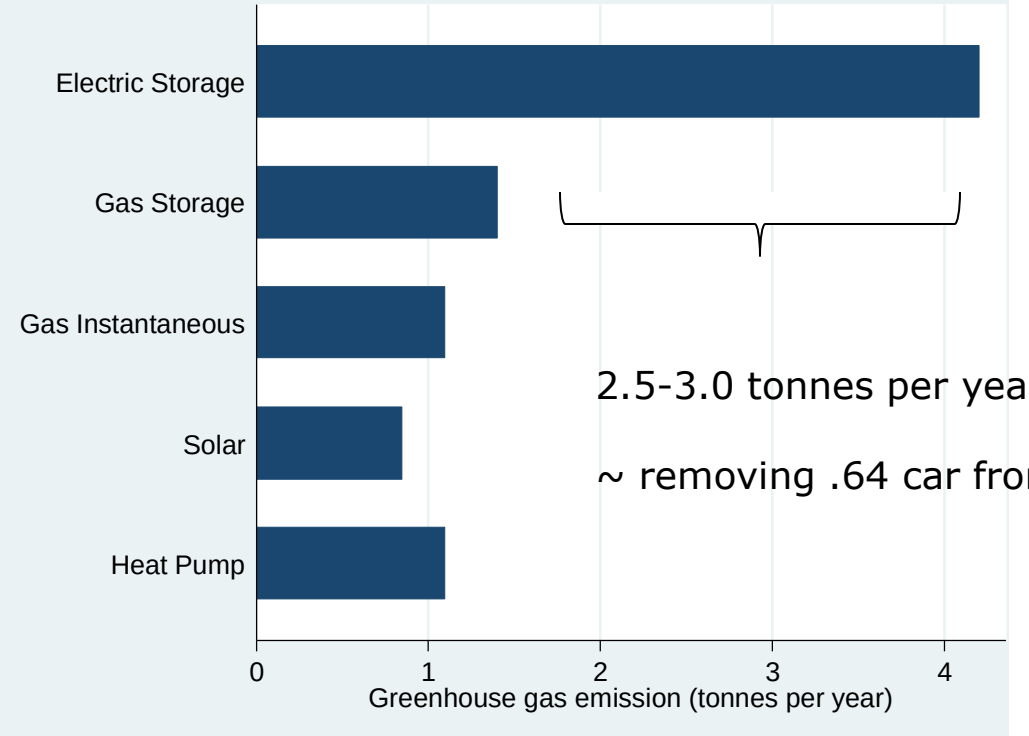
Energy use in NSW residential sector



"Water heating is the largest single source of greenhouse gas emissions from the average Australian home"

Wasi & Carson, Rebates & water heater demand

Greenhouse gas emission by type of water heaters



2.5-3.0 tonnes per year on average

~ removing .64 car from the streets

Background

- Traditionally, most households used electric water heaters
- Share of gas water heaters has risen in the past 3 decades

  Shares of solar and heat pump systems remained relatively small (less than 5% in 2005)

- Their high upfront costs are likely to be the key barrier.

electric /gas storage	$800-$1000
gas instantaneous	$1500-$2000
solar, heat pump	$3000-$5000

Recent rebate programs

Australian Government Solar Rebate program

July 2007: $1000 rebate for solar/heat pump

replace an electric water heater

originally for low income families, later stopped means-testing

NSW Hot water system rebate program

October 2007 – July 2009 : $300 for gas

$600-$1200 for solar/heat pump

replace an electric water heater

except installation to comply with regulation for new houses

This paper

- Assess the effects of these rebate programs on households water heater demand

- Explicit designed a survey to study recent & future demand

  - Households who recently purchased a heater
  - exploit the natural experiment created by the rebate programs

  - Households with an old water heater (likely to be in the market soon)
  - discrete choice experiments

Study design & Data

- Large web-based panel

  9400 invitations sent to NSW homeowner panelists

  during Dec 2009-January 2010

- Recent demand (purchased the heater in 2004 or later)

  # obs = 408 (gas access), 504 (no gas access)

  Future demand (age of current heater 10 years+)

  # obs = 547 (gas access), 354 (no gas access)

- Renewable Energy Credits (REC) = existing rebate since 2001 (baseline situation)

Evidence from A Natural Experiment
(Recent demand/Revealed Preference respondents)

Difference-in-Difference (DID) estimate: Households with gas access

	Before	After	Time difference
Previous type = electric (treatment)	2004-2007	2007-2009	
prob (elec)	**0.28**	**0.19**	-0.09
	(0.04)	(0.04)	(0.06)
prob (gas)	**0.69**	**0.55**	**-0.14**
	(0.04)	(0.06)	(0.07)
prob (solar/heat pump)	**0.03**	**0.26**	**0.23**
	(0.01)	(0.05)	(0.05)
Previous type = electric in early years (control)	2004-2005	2006-2007	
prob (elec)	**0.39**	**0.22**	**-0.17**
	(0.08)	(0.05)	(0.09)
prob (gas)	**0.61**	**0.74**	**0.13**
	(0.08)	(0.05)	(0.09)
prob (solar/heat pump)	0	**0.04**	**0.04**
		(0.02)	(0.02)
Effects of policy on			**DID**
prob (elec)			0.08
			(0.10)
prob (gas)			**-0.27**
			(0.11)
prob (solar/heat pump)			**0.19**
			(0.06)

Difference-in-Difference (DID) estimate: Households with no gas access

	Before	After	Time difference
Previous type = electric (treatment)	2004-2007	2007-2009	
prob (elec)	**0.90**	**0.40**	**-0.50**
	0.02	(0.03)	(0.04)
prob (solar/heat pump)	**0.10**	**0.60**	**0.50**
	0.02	(0.03)	(0.04)
Previous type = electric in early years (control)	2004-2005	2006-2007	
prob (elec)	**0.94**	**0.87**	**-0.07**
	(0.03)	(0.03)	(0.04)
prob (solar/heat pump)	**0.06**	**0.13**	**0.07**
	(0.03)	(0.03)	(0.04)
Effects of policy on			**DID**
prob (elec)			**-0.43**
			(0.06)
prob (solar/heat pump)			**0.43**
			(0.06)

Results

- Also try to incorporate household size, income, expectation on electricity price (likelihood ratio test rejects a larger model)

- An important factor: whether the replacement is done on emergency/urgent basis

Gas access

	Emergency	Nonemergency
prob (solar/heat pump):	+.09	+.24**

No gas access

	Emergency	Nonemergency
prob (solar/heat pump):	+.19**	+.46**

Evidence from Discrete Choice Experiments
(Future demand/Stated Preference respondents)

Designing stated preference survey

- Respondents with an old water heater are presented with a sequence of hypothetical choice scenarios & are asked to state their most preferred choices.

- Frame respondents to think about replacing a water heater in a nonemergency context

- Relevant choices of heaters are determined by:
  1) access to gas network?
  2) water usage (small, medium or large)?

→ 6 types of experiments: 3 usage levels x gas/no gas access

Example of choice scenario for respondents with gas access, medium water usage

	Electric Off-peak 2	Electric peak	Electric Off peak 1	Gas Storage	Gas Instantaneous	Solar	Heat Pump
Upfront cost	1500	1100	1500	1500	2100	4500	3300
Amount of mail-in rebate	-	-		-	300	-	800
Net cost	**1500**	**1100**	**1500**	**1500**	**1800**	**4500**	**2500**
Annual running costs ($/year)	**500**	**800**	**425**	**325**	**275**	**130**	**160**
Which heater is your most Preferred option?	□	□	□	□	□	□	□

Each respondent answers 16 scenarios

Model of purchase decision (Random Utility Model)

Utility of consumer *n* from heater *j* in scenario *t*:

$$U_{njt} = \alpha_{jn} + \delta_{1n}\,\text{costafterrebate}_{njt} + \delta_{2n}\text{dmailin\_rebate}_{njt} + \delta_{3n}\,\text{runcost}_{njt} + \varepsilon_{njt}$$

for n = 1,2,….N; j = 1,…, 5 or 7; t = 1,…,16

α_{jn} : alternative specific constant (unobserved value) for heater j
ε_{njt} : unobserved component

$$prob(y_{njt} = 1) = prob(U_{njt} > U_{nit} \text{ for all } i \neq j)$$

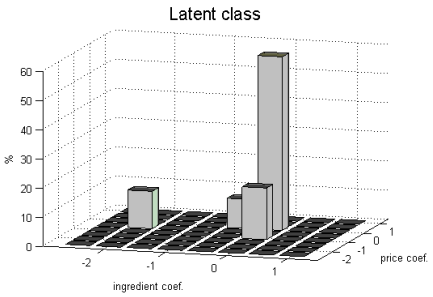
Different assumptions on ε_{njt} and $\{\alpha_{jn}, \delta_{1n}, \delta_{2n}, \delta_{3n}\}$

→ different choice models

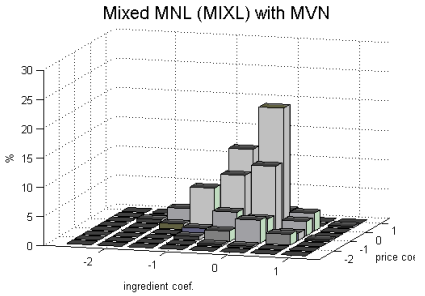
Discrete choice models considered

1. Multinomial logit model "MNL"
   (McFadden,1974)

2. Latent class model
   (Kamakura & Russell, 1989)

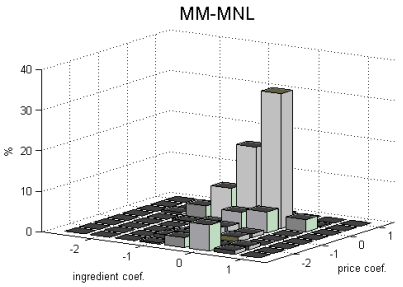


3. Mixed logit model
   (McFadden & Train, 2000)



4. Generalized Multinomial Logit model
   (Fiebig, Keane, Louviere, Wasi, 2010)

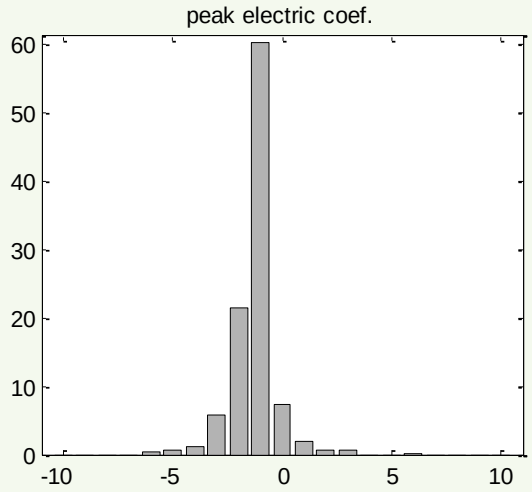
5. Mixture-of-normal mixed logit model
   (Train 2008; Burda et al. 2008; Keane and Wasi, 2010)

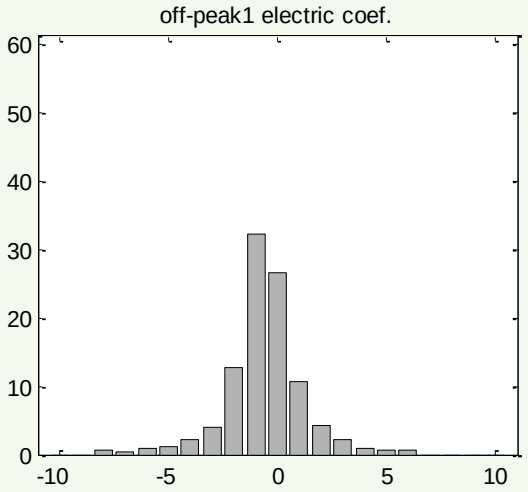


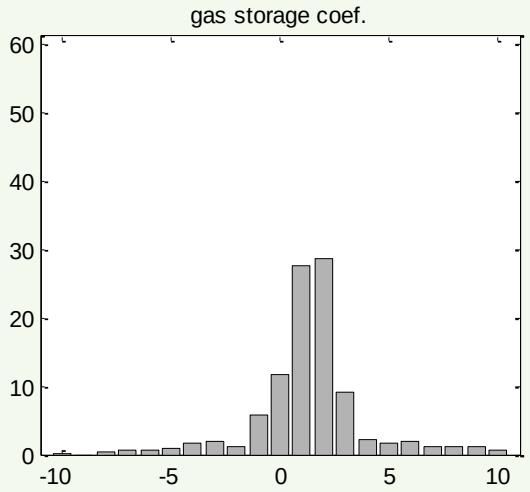
Results: Gas access

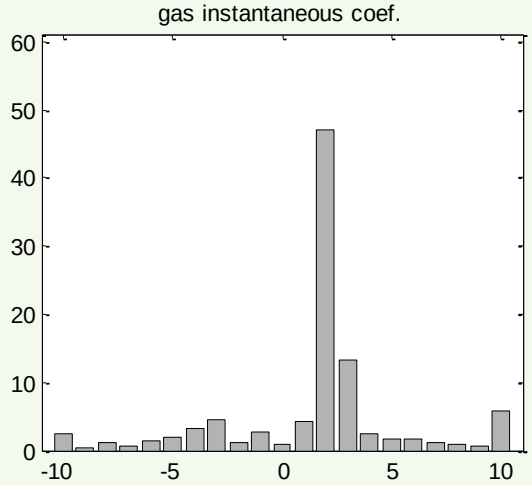
	MNL	Latent class						MIXL (correlated)	G-MNL (correlated)	Mixture-of-normals (2 indep.normals)	
		class 1	class 2	class 3	class 4	class 5	class 6			class 1	class 2
Mean											
(omitted electric off-peak2)											
Electric peak	**0.44**	-0.44	-30	2.14	**0.81**	-30	12.52	**-2.81**	**1.12**	**-1.13**	**-1.35**
Electric off-peak 1	**0.41**	**0.92**	-0.15	0.41	**1.12**	**-2.53**	10.94	**-0.54**	**1.70**	-0.02	**-1.07**
Gas storage	**1.38**	**3.21**	0.1	-0.1	**0.54**	**-1.54**	13.82	**1.83**	**5.64**	**1.69**	**0.90**
Gas instantaneous	**1.73**	**2.59**	**1.35**	-0.01	0.004	***-0.26***	16.06	**2.26**	**6.59**	**2.26**	**1.03**
Solar	**2.5**	**2.86**	**2.01**	**3.91**	**0.9**	0.26	11.81	**3.12**	**7.25**	**2.76**	**1.23**
Heat pump	**1.69**	**1.89**	**2.21**	**2.64**	-0.18	**-4.73**	12.66	**1.30**	**5.32**	**1.56**	**-1.71**
Cost-after-rebate/10000	**-8.62**	**-18.96**	**-17.03**	**-5.73**	**-13.92**	**-11.38**	**-7.74**	**-22.81**	**-26.57**	**-27.30**	**-16.93**
1 if mail-in rebate dummy	0.002	-0.06	**0.25**	-0.003	**-0.29**	0.06	-0.03	-0.04	0.03	0.01	***-0.28***
Annual running cost/1000	**-3.99**	**-5.69**	**-13.12**	**-7.5**	**-1.77**	**-11.29**	**-7.07**	**-16.33**	**-17.94**	**-22.02**	**-9.35**
Covariance	no	no						yes	yes	yes	yes
class prob.		**0.34**	**0.21**	**0.15**	**0.14**	**0.09**	**0.06**			**0.66**	**0.34**
τ									**0.57**		
γ*									0.03		
No. of parameters	9	59						54	56	37	
Loglikelihood	-12861	-8924						-7447	-7198	-7142	
AIC	25740	17967						14933	14508	**14359**	
BIC	25804	18384						15075	14904	**14620**	
CAIC	25813	18443						15095	14960	**14657**	

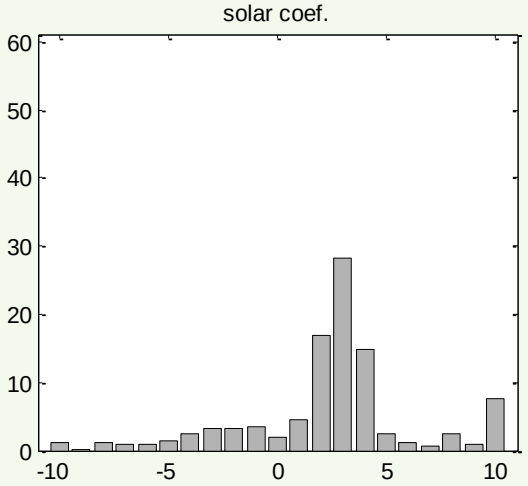
Distribution of taste heterogeneity associated with each type of heater

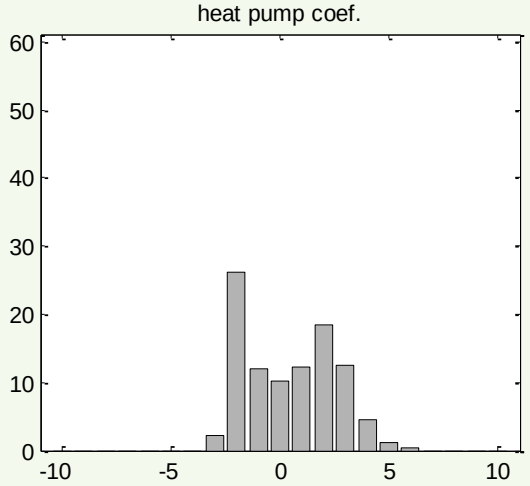












Discount rate

$$U_{njt} = \alpha_{jn} + \delta_{1n}\,\text{costafterrebate}_{njt} + \delta_{2n}\text{dmailin\_rebate}_{njt} + \delta_{3n}\,\text{runcost}_{njt} + \varepsilon_{njt}$$

$\delta_{3n} / \delta_{1n}$ = willingness-to-pay (WTP) to save $1 per year for q years (heater lifetime)

$$= \frac{1}{(1+r)} + \frac{1}{(1+r)^2} + \ldots + \frac{1}{(1+r)^q}$$

Implied individual discount rates	Gas access Freq (%)	No gas access Freq (%)
Less than 2%	22	26
2-10%	22	23
10-20%	24	18
20-40%	16	10
Higher than 40%	15	23
Median discount rate	12%	10%

Prediction

Households who previously own an electric system

Scenario I: change from “no rebate” to “post October 2007 scheme”

	gas access	no gas access
changes in share of solar/heat pump:	20%+	38%+
Actual purchase data, nonemergency	24%+	46%+

Prediction for other rebate scenarios

- If rebates were reduced,

  predict substantial reduction in demand for solar/heat pump

- If households who own nonelectric system (mostly gas) were eligible for rebates for solar/heat pump,

  predict that shares of solar/heat pump 20+%

Conclusions

- Assess the role of hot water system rebate programs on NSW demand for water heaters

- From recent actual purchase data,
  - shares of solar/ heat pump significantly increase.

  - Does it imply reduction in the stock of electric water heaters?
    Yes -- for households with no gas access
    Unlikely -- for households with gas access
    (the increase is offset by the reduction in share of gas heaters)

  - Emergency replacement matters

Conclusions

From stated preference data to predict future demand

- Considerable heterogeneity preference toward different types of water heaters & discount rate
- Mixture-of-normal mixed logit model outperforms other models for these data sets
- Predictions are reasonably consistent with actual purchase data.
- Predict sizeable effects of alternative rebate policies on water heater demand.

Thank you!

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