Further bridging the energy efficiency gap: heterogeneity, model error and persistence

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Introduction

- Contrasting views on energy efficiency?

"There is no realistic, or affordable, energy development strategy that is not led by energy efficiency. For the IEA, it is the first fuel" Fatih Birol (2016)

"Why government energy efficiency programs sound great – but often don't work" Sam Ori, WSJ (2017)

Expectations vs Reality

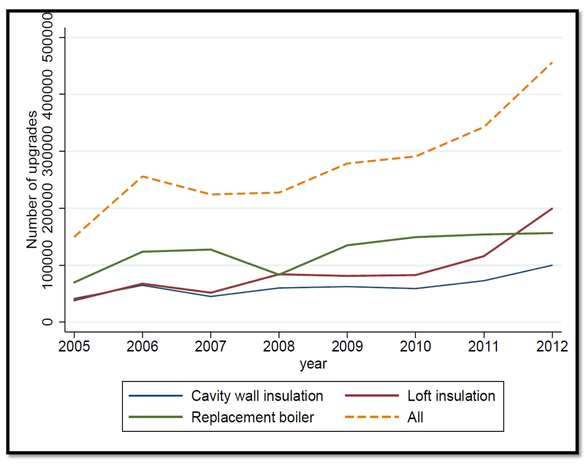
- Market failures, behavioural failures inhibit adoption
- Measurement error is also a significant problem - Actual energy savings 40-60 percent of predicted - Fowlie at al. (2015), Allcott and Greenstone (2017)
- Unobserved costs, overstated savings from adoption, consumer heterogeneity, inappropriate discount rates and uncertainty
- Longer term effects rarely taken into account

Research Questions

1. What degree of heterogeneity, model/measurement error and time-consistency/persistence exist in the returns to energy efficiency?
2. How does this effect the cost-effectiveness of measures, distributional impacts of policies?

Background

- UK 2005-2012. Supplier Obligations primary policy instrument
- Domestic gas usage fell by 27% and electricity by 14% during this period.
- Insulation (66%), lighting (18%) and heating (10%) accounted for main savings.
- Policy evaluations conducted using modelled estimates. How reliable are these results?



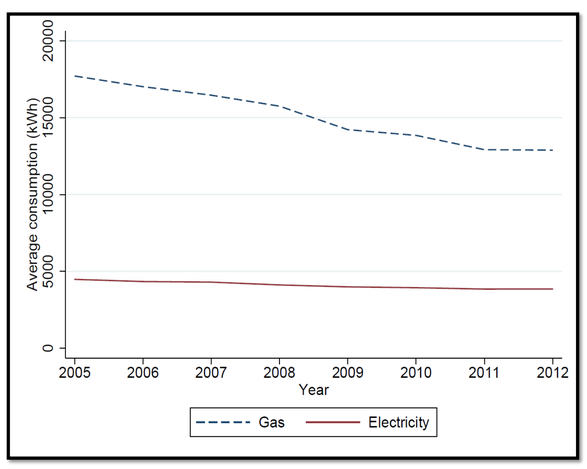


Fig 1 & 2. Measures installed and energy savings (2005-2012)

Empirical approach & Data

- Database of **4 million** households over **8 years**
- **Statistical matching** and **panel econometric estimations** to mitigate unobserved heterogeneity and selection into government schemes
- Population of supplier TWC schemes – mitigate "site selection bias" (Allcott, 2015)

Table 1: National Energy Efficiency Data Framework (NEED)

Variable type	Source
Energy efficiency measures	HEED/Ofgem/DECC
Energy consumption	Energy Suppliers
Property attributes	V.O.A.
Household characteristics	Experian

Econometric Results

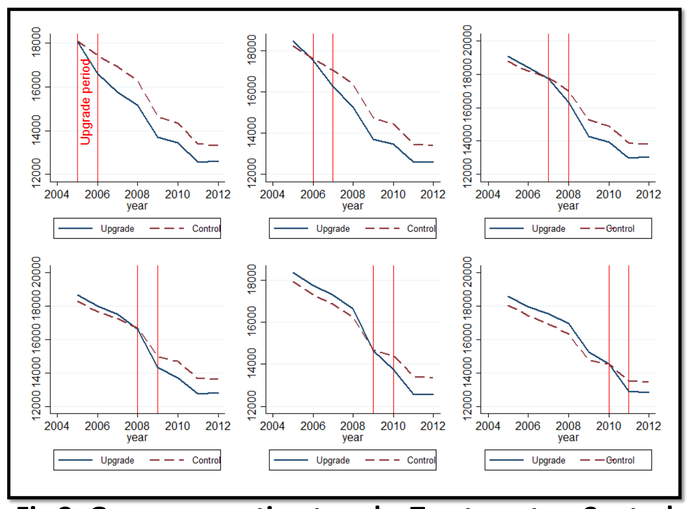


Fig 3. Gas consumption trend – Treatment vs Control group

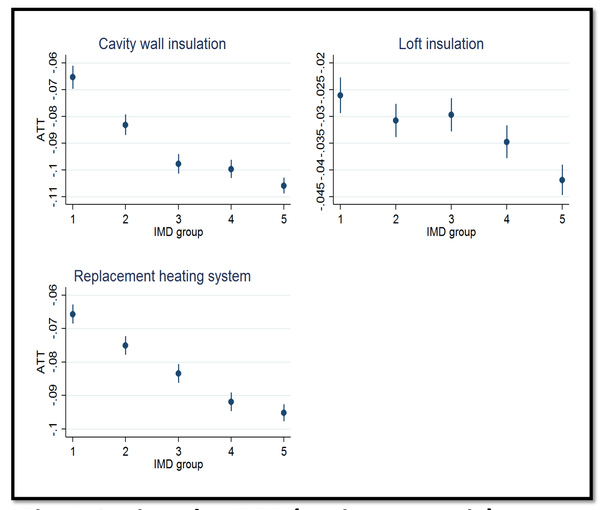


Fig 4. Savings by IMD (socioeconomic) group and measure

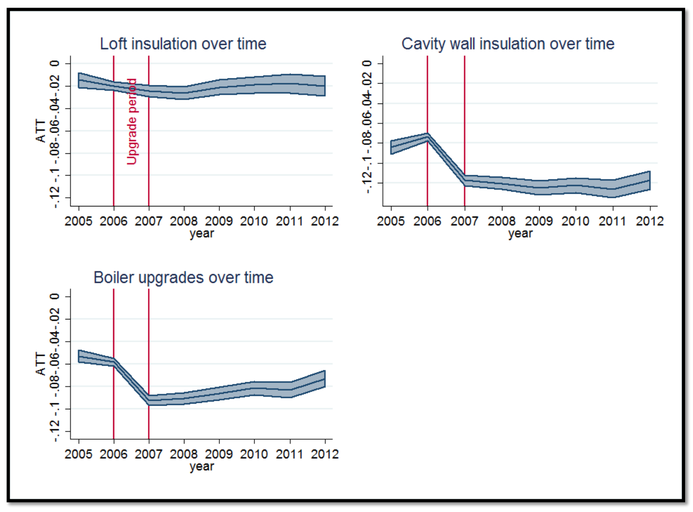


Fig 5. Energy savings over time

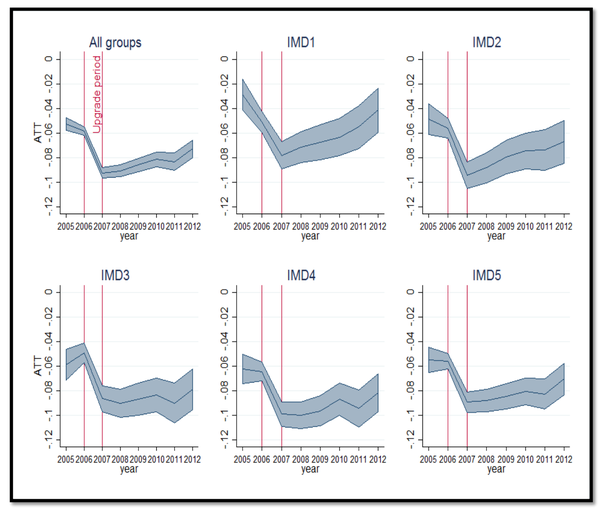


Fig 6. Boiler savings by IMD group

Comparison with Engineering models

Table 2. Actual vs predicted savings

Measures installed	SAP predicted (kWh)	Actual (kWh)	% predicted
Cavity wall	5153	1278	25%
Loft insulation	2703	384	14%
Boiler	3588	1328	37%

Cost Effectiveness

- Calculate NPVs for range of cost estimates, price scenarios and discount rates
- Cavity wall and loft NPV - depends on discount rates and future prices
- Boiler NPV - depends on expected lifetime and cost assumptions (£700-£6000!!)

	p-5	p-4	p-3	p-2	p-1	p0	p1	p2	p3	p4	p5
1%	497	542	592	650	715	789	872	968	1076	1199	1339
2%	290	323	361	404	452	507	569	640	721	812	917
3%	137	162	190	222	258	299	346	398	458	527	605
3.5%	76	98	122	150	181	216	257	302	354	413	481
4%	24	43	64	88	115	145	180	220	265	316	374
5%	-60	-46	-30	-12	8	31	57	87	121	159	203
6%	-122	-112	-100	-86	-71	-54	-34	-12	13	42	75

	p-5	p-4	p-3	p-2	p-1	p0	p1	p2	p3	p4	p5
1%	69	81	95	111	129	149	172	198	227	261	299
2%	12	22	32	44	57	72	89	108	130	155	184
3%	-29	-22	-15	-6	4	15	28	42	59	77	99
3.5%	-46	-40	-33	-26	-17	-8	3	16	30	46	65
4%	-60	-55	-49	-43	-35	-27	-17	-7	6	20	35
5%	-83	-79	-75	-70	-64	-58	-51	-43	-34	-23	-11
6%	-100	-97	-94	-90	-86	-81	-76	-70	-63	-55	-46

Fig 7 & 8. NPV of cavity and loft insulation for various price forecasts and discount rates

Table 3. Cost per tonne of CO2 removed

Measures installed	Total Savings (kg)	Total Savings (tonnes)	Cost (£)	£/tonne of CO2
Cavity wall insulation	9608	10	312	33
Loft insulation	3178	3	152	48
Replacement boiler	3334	3	200	60

Summary

1. Large gap between predicted and actual savings – **policy evaluations need to use ex-post data**
2. Savings much larger for higher income households
3. Measures still broadly NPV positive
4. Costs above typical estimates of SCC
5. High level of uncertainty – costs, energy prices, long term performance

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