BASQUE CENTRE
FOR CLIMATE CHANGE
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The Determinants of Energy Efficiency Investments in the U.S.

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Index

1. Introduction

- Energy Efficiency (EE) has impact in:
  - Fossil fuel consumption.
  - GHG emissions.
  - Security of supply.
  - Competitiveness.
- However, many investments that appear profitable, are simply not made. This is known as the "energy efficiency paradox". Several explanations:
  - Barriers as insufficient information.
  - Principal-agent problems.
  - Access to capital markets.
  - Risks.
  - Divergence between private and social discount rates.
  - Other.
- Understanding better what drives EE decisions is important!

2. The Industrial Assessment Centres Program (IAC)

- Department for Energy (US), directed to Small and Medium Enterprises (SME) in the manufacturing sector. (Since 1978).
- Undertaken by staff and students from many Universities.
- Requirements to apply:
  - Gross sales of US$ 100 million per annum or less.
  - Energy costs of between $100,000 and $2.5 million per year.
  - No more than 500 employees.
  - No in-house technical specialists capable of performing investment analysis.
  - A location no more than 150 miles from the campus of the participating centre that performs the assessment.
- To date 04/15/2010 more than 14,000 assessments and more that 108,000 recommendations.
- The IAC database lacks information on **the lifetime of each recommendation.**

3. Previous studies:

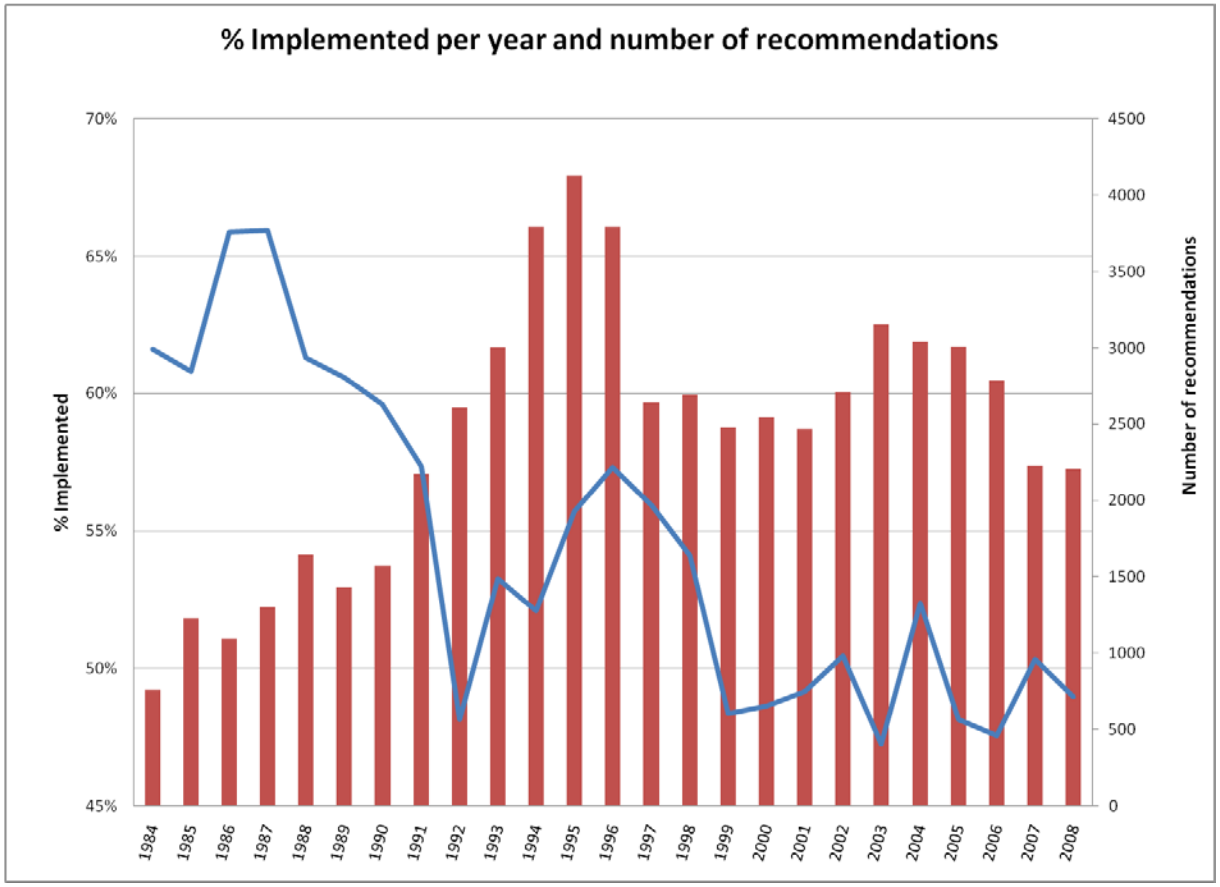
- Tonn and Martín (2000): **Corporate decision-making** model. Questionnaires sent to firms. **Best opportunities come first!**
- Anderson and Newell (2004): Logit models. Firms more sensitive to **shorter payback periods** and **lower investment cost** than to greater **annual energy savings**. Consistent with EE paradox!
- Muthulingam et al (2009) test four hypotheses: (a) the **short-sightedness** of firms that fail to adopt certain EE measures in spite of their high rate of return; (b) the idea that firms give **more importance to the cost of investment** than to the potential savings; (c) the possible influence of the **order in which assessment recommendations are made**, and (d) the impact of **the number of recommendations**.

  Hypothesis (a), (b) and (c) hold! Consistent with EE paradox!

4. The Basic idea

- The present paper looks to this in greater detail by estimating various decision-making models but differs from earlier studies in that **it does not assess the suitability of the actions taken by firms.**
- The main objective is to help **identify measures to support investment in EE that may be useful in decision-making and in public policy design**, given that firms behave as reported in the IAC Database.
- The study refers solely to **electricity-related EE investments.** In particular, looking at sensitivity of the implementation rate to changes in the various variables considered.
- The sample for analysis comprise **60,463** recommendations, with an acceptance rate of only **53.17%.** Years 1984-2008.

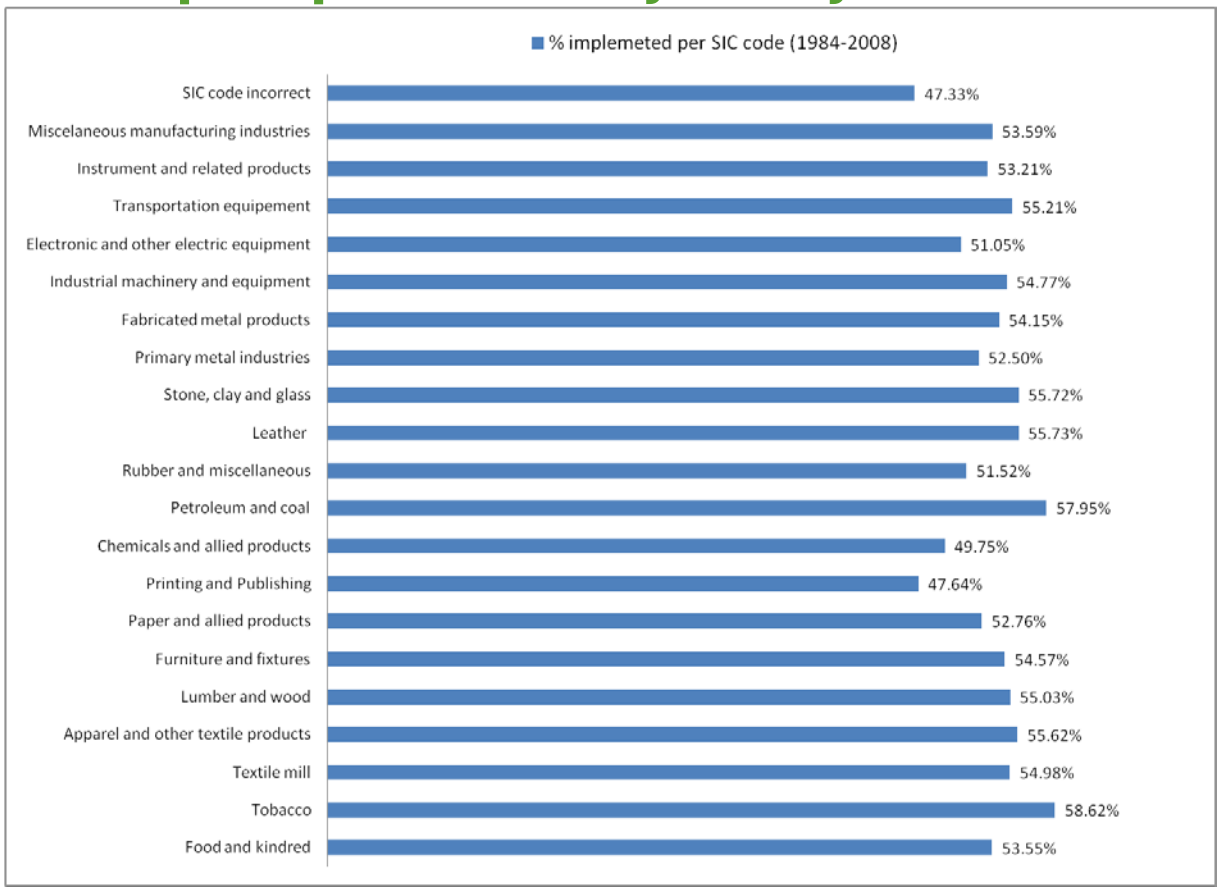
5. The sample: preliminary analysis



- On average, almost half (47%) of the recommendations do not result in an investment decision!
- Years with highest implementation rate 1984-89!
- Lowest 2000-08!

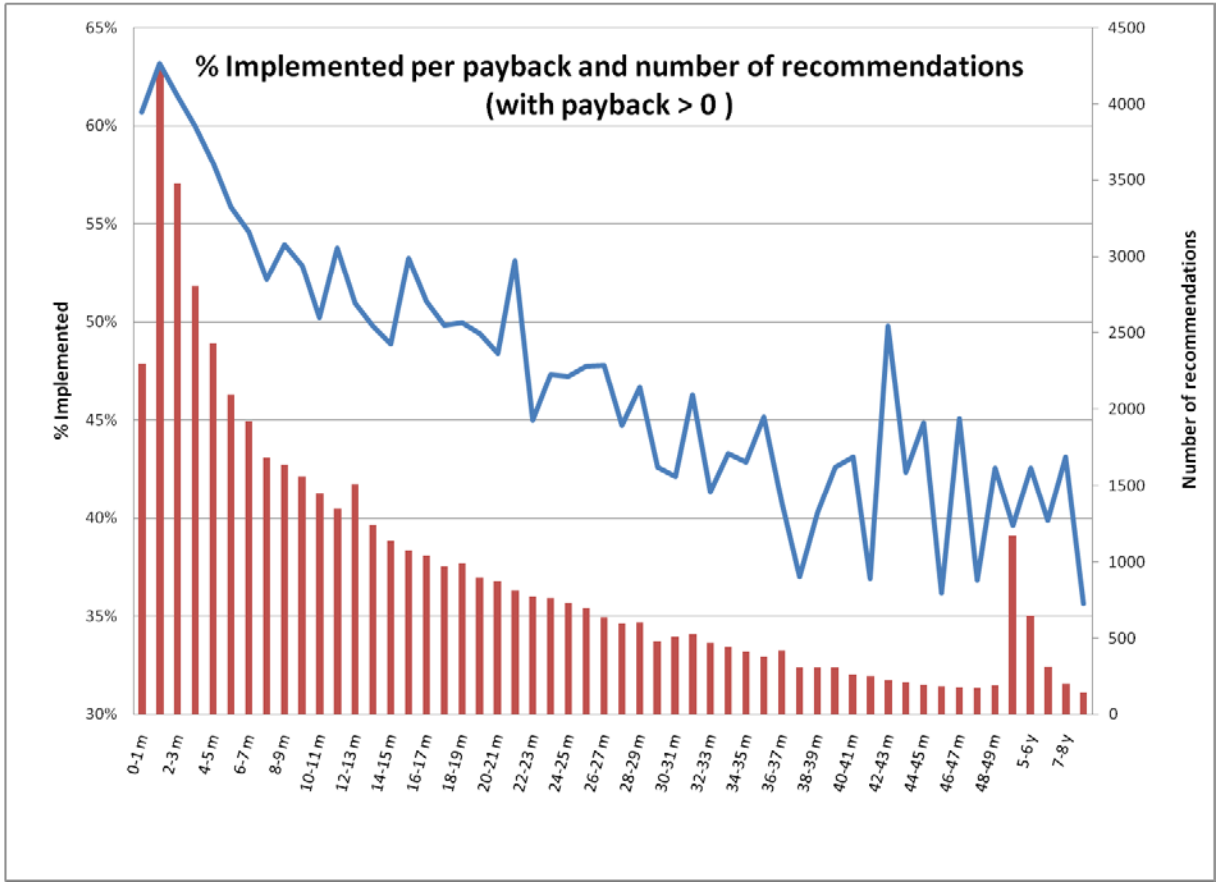
- Depletion effect (best investment opportunities first)!

5. The sample: preliminary analysis



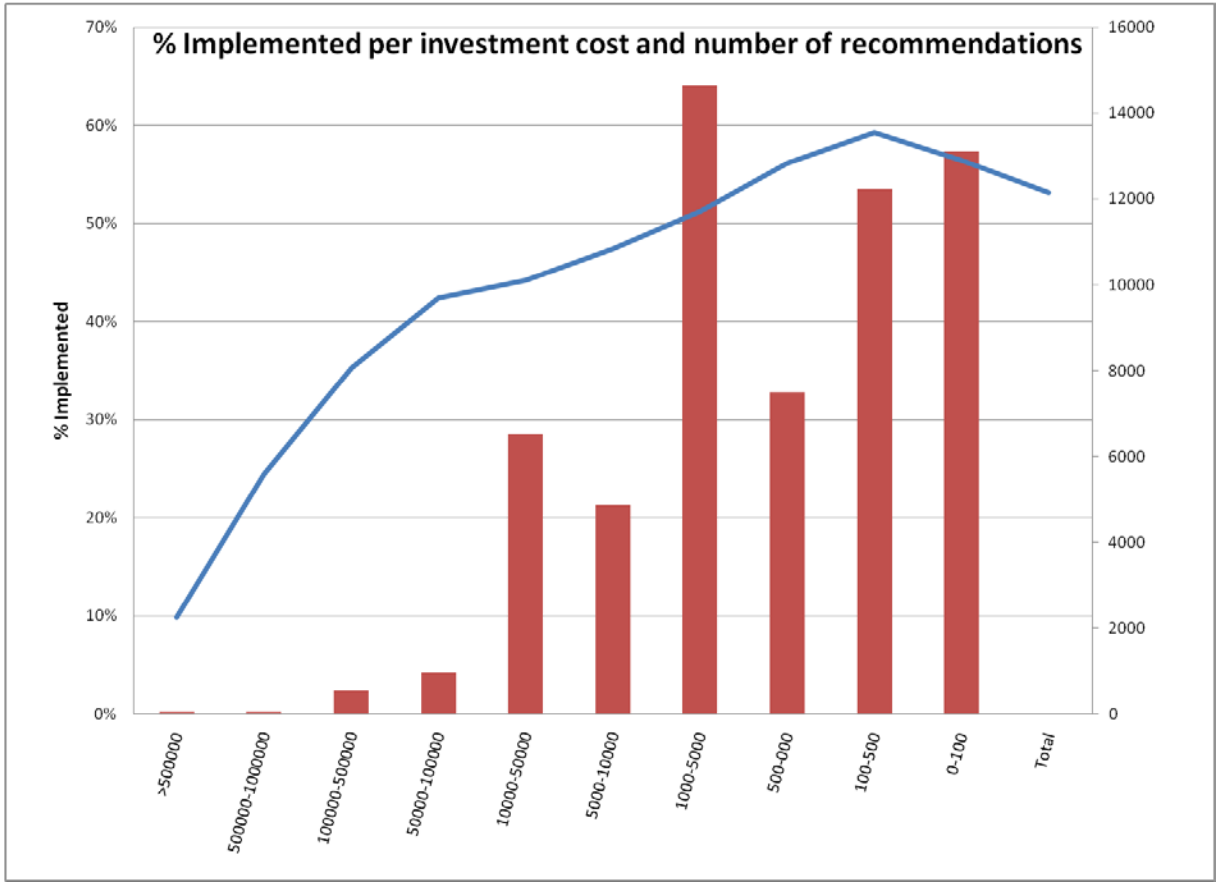
- Variation rate between 47% to 57%!
- Great disparity on the implementations among industries!

5. The sample: preliminary analysis



- Consistent with previous studies, Payback time determining factor!

5. The sample: preliminary analysis



- The acceptance rate falls markedly as the cost of investment increases!

6. The Model: PROBIT (choice of implementing or not)

$$y^{*}_{ijklmn} = \psi(A_i, B_j, C_k, D_l, E_m, F_n) + \epsilon$$

- Where sub-indices to:
  - (i) The characteristics of the EE investment project;
  - (j) The characteristics of the firm;
  - (k) The state in which firms are located and those variables that may differ from one US state to another (e.g. environmental legislation, idiosyncratic features of employers, etc.);
  - (l) The influence of the Standard Industrial Classification (SIC) group to which firms belong;
  - (m) The impact of the type of investment as per its Assessment Recommendation Code (ARC);
  - (n) The influence of the IAC Centre that performs the assessment.
- The probability of an investment being made can be obtained from:

$$\Pr[y_{ijklmn} = 1] = \Phi\left(\psi(A_i, B_j, C_k, D_l, E_m, F_n)\right)$$

6. The Model: PROBIT (choice of implementing or not)

- Details of variables

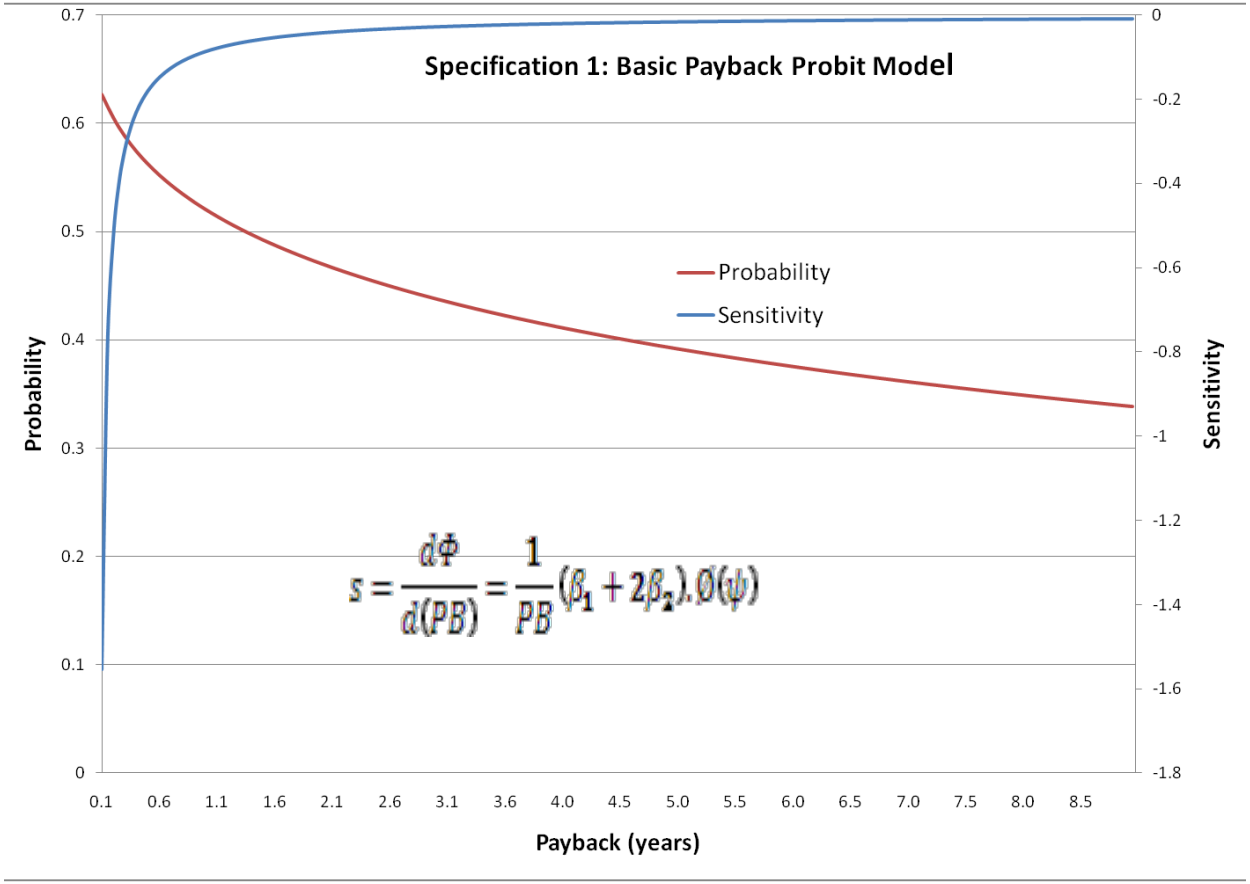
Variable	Acronym	Obs.	Mean	Std. Dev.
payback time	PB	60,463	1.1082	1.3450
ln(payback time)	ln(PB)	51,220	-0.4119	1.4034
ln(payback time)^2	ln(PB)^2	51,220	2.1393	4.1873
State GDP	GDP	60,464	45,145.28	39684.13
ln(State GDP)	ln(GDP)	60,463	10.3101	0.9725
ln(State GDP)^2	ln(GDP)^2	60,463	107,2435	19.6947
Emissions	EMI	49,918	197,2448	159.7737
ln(Emissions)	ln(EMI)	49,918	4,9738	0.8237
Year	YEAR	60,463	1997.433	6.32228
Ln(EE Cost)	Ln(Cost)	50,953	7.202315	1.919909
Ln(Yearly EE Benefits)	Ln(BEN)	60,449	7.570395	1.504785

6.1. The Model: Payback time only

$$\psi = \beta_0 + \beta_1 . \ln(PB_i) + \beta_2 . \ln(PB_i)^2 + \varepsilon$$

Probit regression				Number of obs = 51220		
				Wald chi2(2) = 928.72		
				Prob > chi2 = 0.0000		
Log pseudolikelihood = -34972.098				Pseudo R2 = 0.0132		
Impstat	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
ln(*PB*)	-0.16052	0.005765	-27.85	0	-0.17182	-0.14922
$\ln(PB)^2$	-0.02236	0.001959	-11.42	0	-0.0262	-0.01852
constant	0.043845	0.006291	6.97	0	0.031514	0.056175

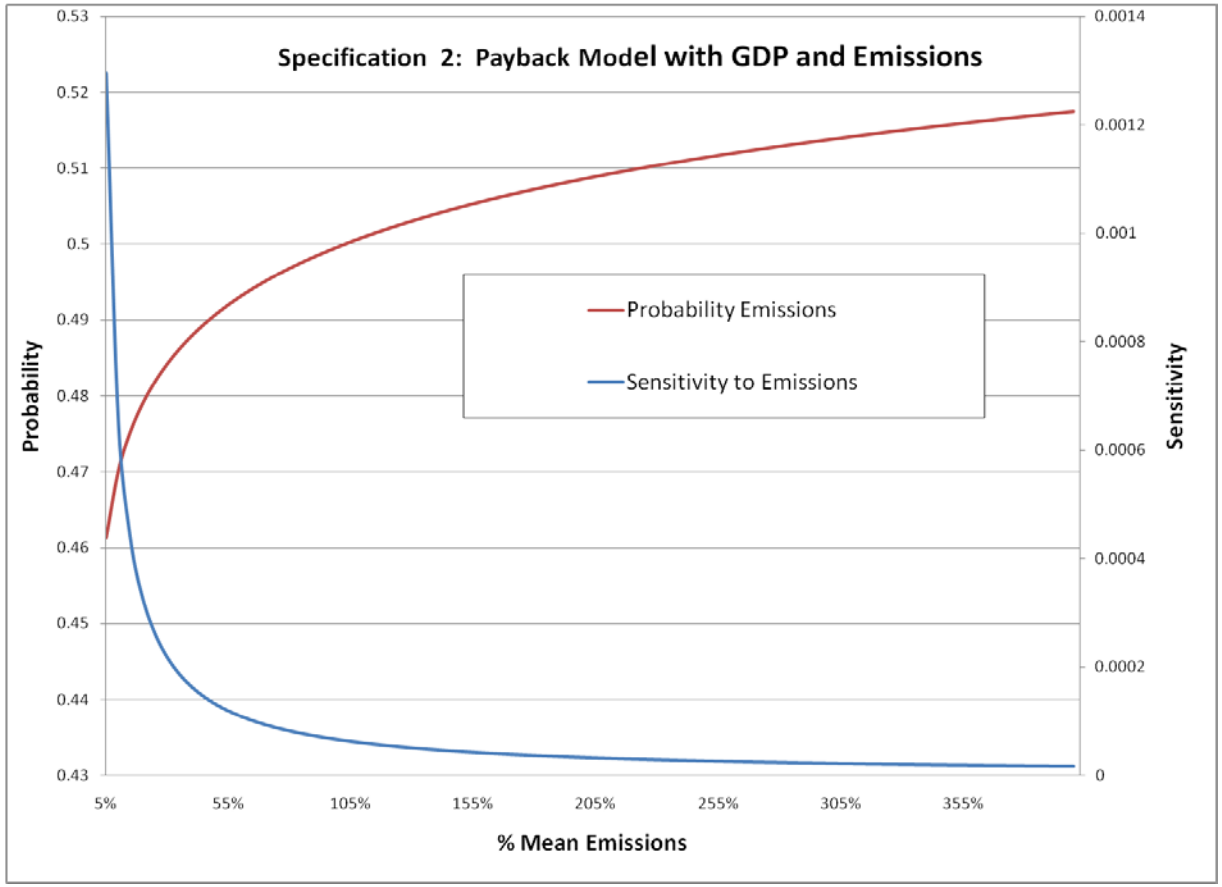
6.1. The Model: Payback time only



Payback=Investment cost/ annual saving.

- Sensitivity of the Pr of implementing depends on payback. Huge increase after 1 year.
- Increases in payback time reduces likelihood of implementing!
- Policies intended to reduce payback might be effective!

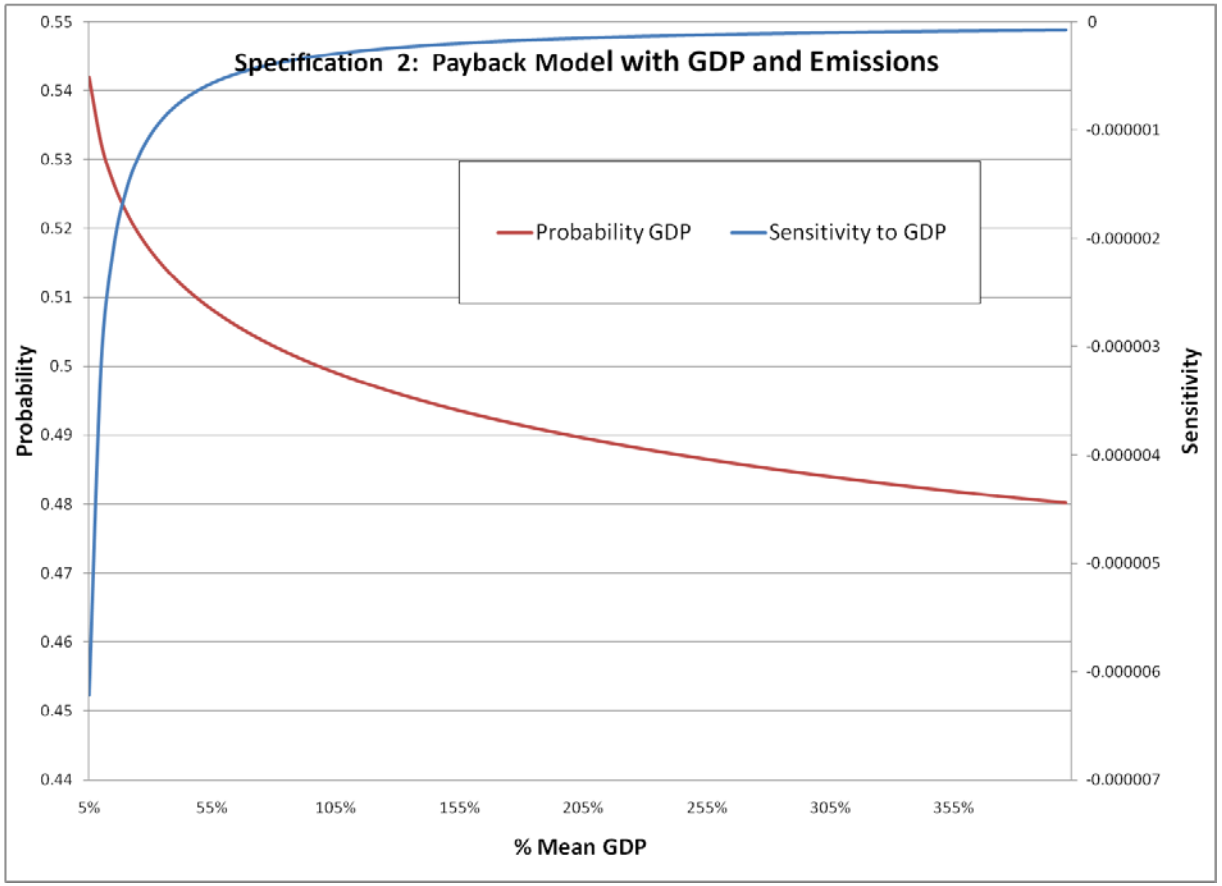
6.2. The Model: Payback +State variables (GDP and Emissions)



- Firms located in states with highest GHG emissions more likely to invest in EE. Probably because Marginal Benefit of Abatement higher!

$$\psi = \beta_0 + \beta_1 . \ln(PB_i) + \beta_2 . \ln(PB_i)^2 + \beta_3 . \ln(GDP_k) + \beta_4 . \ln(\mathrm{EMI}_k) + \varepsilon$$

6.2. The Model: Payback +State variables (GDP and Emissions)



- Firms in states with highest GDP (manufacturing industry) are less likely to invest. Paradox!
- Maybe has to do with firms in richer states not applying for the IAC program?

$$\psi = \beta_0 + \beta_1 . \ln(PB_i) + \beta_2 . \ln(PB_i)^2 + \beta_3 . \ln(GDP_k) + \beta_4 . \ln(\mathrm{EMI}_k) + \varepsilon$$

6.3. The Model: Payback +State variables (GDP and Emissions) and assessments centres and sectors

$$\psi = \beta_0 + \beta_1 \ln(PB_i) + \beta_2 \ln(PB_i)^2 + \beta_3 \ln(GDP_k) + \beta_4 FY + \beta_5 . \ln(EMI_k) +$$

$$\overline{state}.\overline{\beta_6} + \overline{center}.\overline{\beta_7} + \overline{SIC}.\overline{\beta_8} + \overline{ARC}.\overline{\beta_9} + \varepsilon,$$

- The results hold but difficult to interpret why some sectors or some states more sensible to implementing EE as a consequence of IAC programme.

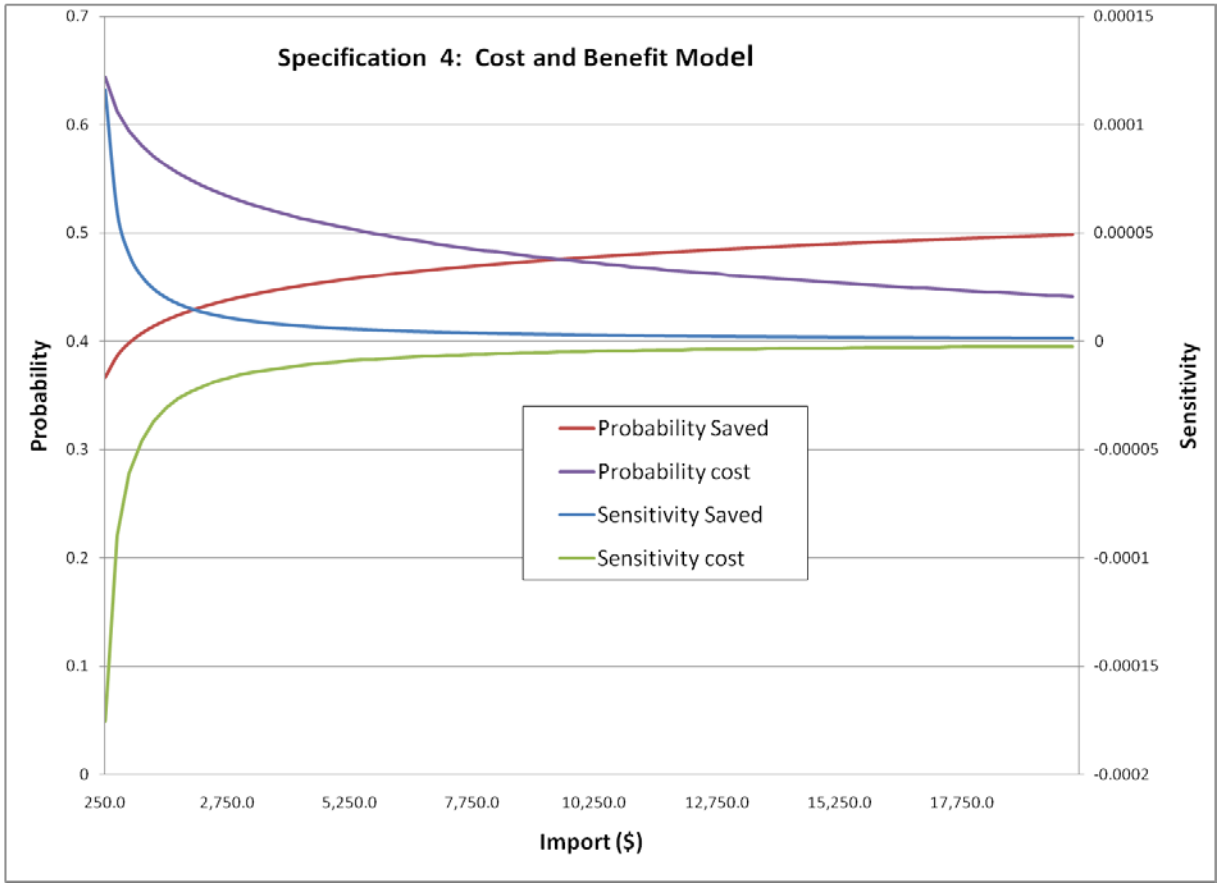
- The same applies to rate of success of some of the centres. Might be some reputational effect?

6.4. The Model: The Cost-Benefit Model

$$\psi = \beta_0 + \beta_1 . \ln(COST) + \beta_2 . \ln(BEN) + \varepsilon$$

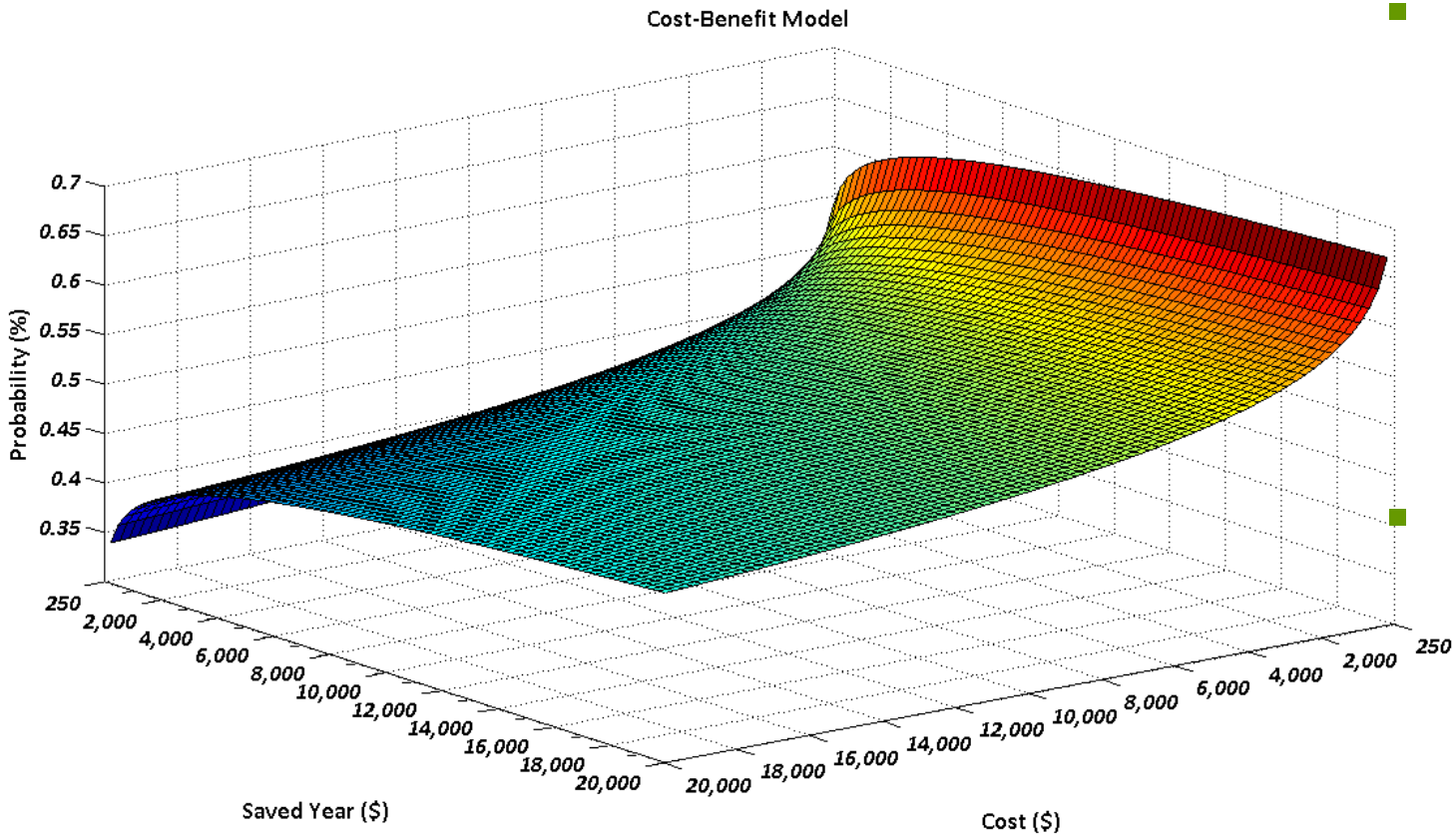
Probit regression				Number of obs = 50944		
				Wald chi2(4) = 859.87		
				Prob > chi2 = 0.0000		
Log pseudolikelihood = -34775.715				Pseudo R2 = 0.0131		
Impstat	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
ln(COST)	-0.1176	0.0041	-28.49	0.000	-0.1256	-0.1095
ln(BEN)	0.0770	0.0052	14.89	0.000	0.0669	0.0872
Constant	0.3296	0.0289	11.40	0.000	0.2729	0.3862

6.4. The Model: The Cost-Benefit Model



- The cost factor has a greater impact than potential medium long term benefits.
- Consistent with other studies, energy efficiency paradox!
- Similar to observed behaviour at individual level (Markandya et al, 2009)

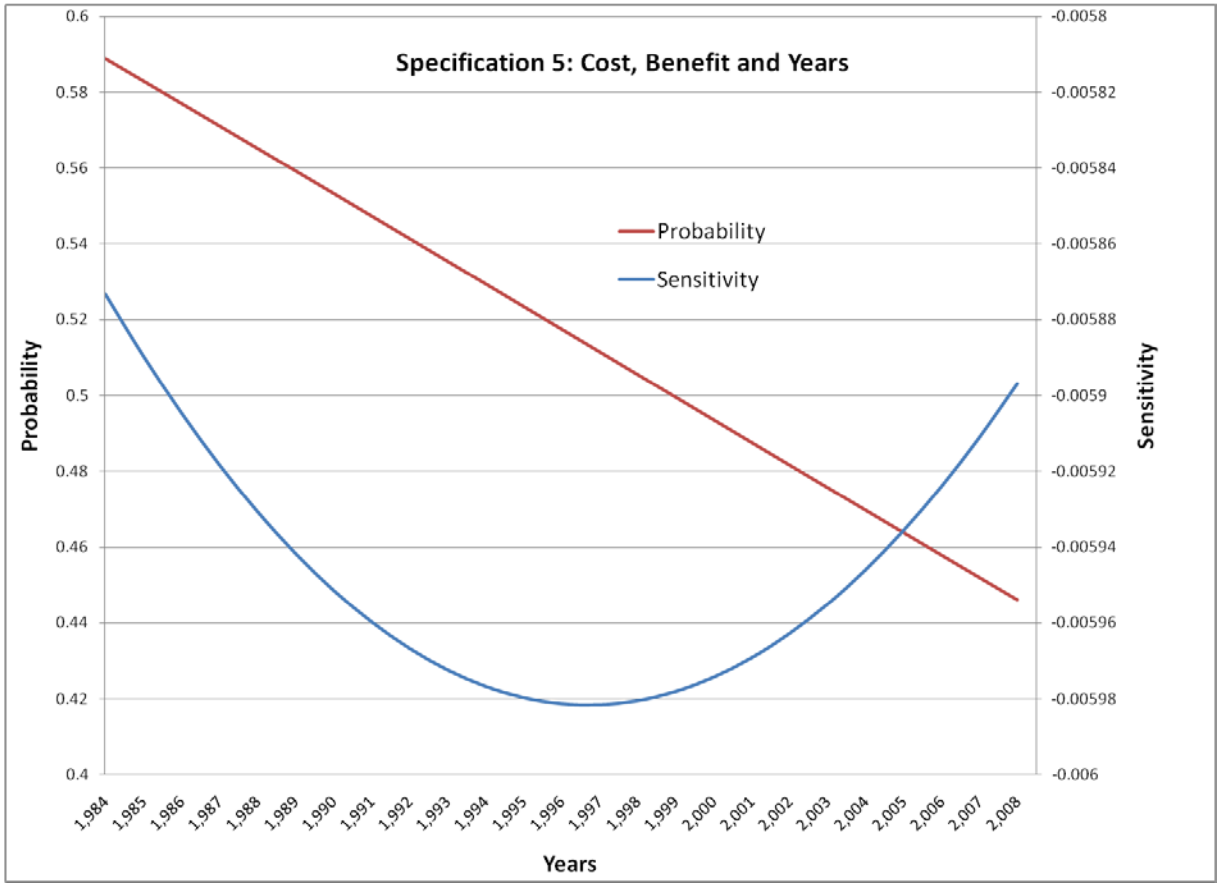
6.4. The Model: The Cost-Benefit Model



- The highest the potential savings and the lower the EE investment cost the greater the probability!
- Even in very favourable cases probability does not exceed 70%!

$$\psi = \beta_0 + \beta_1 . \ln(COST) + \beta_2 . \ln(BEN) + \varepsilon$$

6.5. The Model: The Cost-Benefit and Years Model



$$\psi = \beta_0 + \beta_1 . \ln(COST) + \beta_2 . \ln(BEN) + \beta_3 . \ln(YEAR) + \varepsilon$$

- The passage of time influences negatively the probability of the investment decision.
- Maybe depletion effect mentioned earlier as an intuition?
- We have tried a couple of more models with similar results! (states, years, centres, sectors, etc.)

7. Further research

- Further research suggests **unravelling the relationship** among the **propensity to invest in EE and the environmental stringency** in those states where companies are located.
- For this we have used **the Industry Adjusted Index of State Environmental Compliance Cost** (Levinson, 2001), BUT only available for 1984-1994. This lead to 15,600 observations.
- **Positive and significant** variable! Might be worth exploring further!

8. Policy Implications and Conclusions

- **Depletion effect** in investment opportunities.
- **Payback** is determinant in investment decisions.
- Changes in **payback** have **a non-linear influence.**
- The **Probability** and **Sensitivity** vary depending on the value of variables.
- Firms located in states with **highest levels of GHG** emissions are **more likely to invest** in EE.
- Firms located in states with **Highest GDP** from manufacturing **industry are less likely to invest** in EE. Paradox!
- Ceiling seem to at **70%** probability.
- **Cost reduction** has a **greater impact than expected saving** → policies that focus on cost should be more effective in getting firms to make investments in energy efficiency.

Many thanks!

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