Adoption of Energy Efficiency Initiatives – Evidence from Energy Audits of Small and Medium Firms

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AOM – Doctoral Consortium

Agenda

- Background
- Introduction
- Literature Review
- Hypothesis Development
- Methodology and Results
- Conclusion

Background

- ***Work Experience*** – Over 13 years; Coopers & Lybrand, PwC, IBM
  - Business Consulting with specific focus on Operations
- ***Dissertation*** – "Adoption of Sustainable Operating Practices"
- ***Current Stage*** – 4th year in PhD program at UCLA. Expect to Graduate in June 2009
- ***Advisor*** – Prof Charles Corbett

- ***Research Agenda*** - establish pursuing sustainable operating practices not only leads to a positive environmental outcome but also leads to better business performance

Introduction

- GHG emission increased by 70% between 1970 and 2004
- Global GHG concentrations were 379 ppm in 2005
  - 35% more than pre industrial levels (IPCC 2007a).

- Energy efficiency - a key strategy to reduce CO2 emissions.

- IPCC 2007 report states… *"mitigation opportunities with negative costs have the potential to reduce emissions by 6 GtCo2 – eq/yr in 2030. Realizing these requires dealing with implementation barriers."*

Introduction

- A considerable body of evidence indicates that many energy efficiency investments are not undertaken
- Decanio (1993) → many energy efficiency investments not made despite their apparent profitability.
- United Nations Foundations report (UNF 2007) cites many recent studies → significant proportion of energy efficiency improvement potential is untapped.
- Various studies have postulated theories and explanations for this apparent anomaly.

Introduction

- However the behavioral aspects related to adoption of energy efficiency initiatives have largely been unexplored.
- We study the role of bias in the adoption of energy efficiency initiatives.
- We identify specific biases and estimate their impact
- Using a database of energy saving initiatives maintained under the auspices of the US Department of Energy (DOE)

Literature Review

- The work seeks to draw and build on many streams of literature
- Environmental initiatives provide many benefits
  - Porter and Van der Linde (1995); Klassen and Whybark (1999); King and Lennox (2002); Corbett and Klassen (2006)
- There are many energy efficiency improvement opportunities
  - Shama (1983); Lovins and Lovins (1993); Decanio (1993); Jaffe and Stavins (1994a)
- Various studies/ theories to explain energy efficiency gap
  - Jaffe and Stavins (1994b); Hassett and Metcalf (1993); Decanio (1998)
- Most of the attempts to explain adoption are assuming agents are rational

Literature Review

- However this may not be always true Kahneman (1994) ; People may adopt heuristics / rules of thumb - (Gilovich, Griffin, and Kahneman, 2002).
- The operations field also has many studies that highlight examples
  - Corson and Donahue (2006); Bendoly et al. (2006)
- Decision problem when you need to allocate assets across many choices or make decisions when there are many choices
  - Benartzi and Thaler (2001); . Huberman and Jiang(2006); Iyengar and Lepper (2000)

Data

- DOE through its IAC program provides free energy assessments for small and medium sized manufacturing firms.
- Assessments identify a range of improvements spanning energy efficiency, waste reduction and productivity enhancement.
- Assessments are done by faculty and students of accredited universities
- Information on these assessments is collected and maintained in a database
- Information pertains to the type of recommendations, savings, costs, other recommendation characteristics and firm characteristics

Data

- Adoption rates are around 50%
  - though average payback is just over a year
- Adoption rates are lower for categories with lower payback !

Broad Recommendation Category	Adoption Rate	Average Payback (years)
Energy Savings	0.51	1.09
Waste Reduction	0.40	0.88
Productivity Enhancement	0.42	0.81

Monetary figures are in 2006 US Dollars

- Economic theory suggests a decision maker will adopt recommendations with rates of return over a threshold.
- Not borne out by the low adoption rates

Hypotheses

- Kahneman and Tversky (1979) distinguish a phase of framing and editing followed by a phase of evaluation in a choice process.
- Framing organizes & reformulates the options to simplify evaluation
- Framing is influenced by the way the choice problem is presented

- **Hypothesis 1:** *The order in which recommendations are presented will influence adoption rates. Recommendations which occur in the beginning of the report will have higher adoption rates as compared to recommendations which occur towards the end of the report.*

Hypotheses

- Benartzi and Thaler (2007) discuss decision problem of allocating assets over a set of choices.
- Many adopt a naïve strategy of allocating assets equally over n choices. -- "1/n rule".
- Huberman and Jiang(2006) identify the "conditional 1/n rule" when number of choices is large
- Iyengar and Lepper (2000) find limited choices facilitate purchase
- **Hypothesis 2:** *Adoption rates will fall as more recommendations are made in an assessment. So assessments with fewer recommendations will have a higher adoption rate as compared to assessments with more recommendations.*

Methodology and Results

- Three stage approach
- Preliminary Analysis – Cross Tabulation & ANOVA analysis
- Conditional Logit Model
- Probit Instrumental Variables Model

Methodology and Results

- ***Econometric Specification for the Conditional Logit Model***

- Choice problem is defined by the latent variable model.

- $Y_i^* = \alpha + Financial_i * \beta + Category_i * \gamma + Order_i * \delta + Int\_NPB_i * \psi + Control_i * \lambda + \varepsilon_i$ …(1)

- Y_i^* → net benefit of adopting the recommendation i
- $Financial_i$ → vector of financial variables
- $Category_i$ → vector which classifies the type of recommendation i,
- $Order_i$ → order of the recommendation,
- Int_NPB_i → interaction of # of recommendations with the payback
- $Control_i$ → vector of controls (firm level fixed effects)
- ε_i → error term.

Methodology and Results

- ***Specification for Probit Instrumental Variables Model***

- $Y_i^* = \alpha + Financial_i * \beta + Category_i * \gamma + Order_i * \delta + Number_i * \omega + Int\_NPB_i * \psi + Control_i * \lambda + \varepsilon_i$ (2)

- Y_i^* → net benefit of adopting the recommendation i
- $Financial_i$ → vector of financial variables
- $Category_i$ → vector which classifies the type of recommendation i,
- $Order_i$ → order of the recommendation,
- $Number_i$ → number of the recommendation
- Int_NPB_i → interaction of # of recommendations with the payback
- $Control_i$ → vector of controls (sales, plant area, year, IAC, employees)
- ε_i → error term.

- Instruments -> based on coding of recommendations + propensity of IAC to make different types of recommendations

Methodology and Results

- ***Order of Recommendations are significant***
  - Recommendations that occur later in the report have lower rates of adoption.
- ***The number of recommendation are significant***
  - Assessments with more recommendation have higher adoption rates

Conclusions

- ***Implications of our results***
- IAC must take specific care on the order in which they present the recommendations
- IAC should focus on providing a larger set of recommendations and not restrict themselves to only attractive recommendations
- Possible implication for other areas…

Future Work

- Spatial and Temporal Diffusion of energy efficiency practices across the US
- Effect of the internet on dissemination of information and does it lead to increased adoption
- Field experiment to confirm the findings of the econometric analysis

End of Presentation