



## Funded Project Final Survey Report

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**Principal Investigator:** Prof Matthew Harding

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**Project Title:** Appliance Efficiency and Long-Run Energy Demand

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### **1. Project Description:**

#### **Summary:**

The aim of this project was two-fold:

On the one hand, I proposed to use existing data to investigate the extent to which individuals may be subject to incentive problems. For example individuals may purchase energy inefficient appliances because of the lower up front cost and not fully internalize the individual and public benefits of investing in energy efficient technology. Individuals however may also suffer from a more subtle class of incentive problems commonly known as “split incentives” in the energy efficiency literature. Take for example the case of a landlord and a tenant. Depending on their contractual arrangements, it is possible for the landlord to invest sub-optimally in energy efficient appliances and home insulation when the tenant pays the energy bills or alternatively for the tenant to fail to engage in energy saving activities when he doesn’t pay the bills. This complex set of behavioral motivations may lead to the imperfect energy consumption patterns with consequences for long-run energy demand.

Additionally, I proposed to conduct a detailed investigation of existing datasets in order to establish their suitability for estimating detailed structural models of energy demand. The focus was on establishing the shortcomings of current sources and exploring the feasibility of additional data collection initiatives designed to improve our ability to analyze durable goods purchase behavior. This was meant to emphasize the need for the rigorous measurement of consumer choices and behaviors in order to address the need for developing an optimal long-run energy policy.

#### **Research Activities:**

Core research activities centered on the following areas:

1. Identification, compilation and evaluation of existing household level surveys of household energy demand
2. Developing methods to address statistical challenges such as measurement error or dimensionality reduction in large surveys of household energy use
3. Developing economic models of how behavioral and economic incentive structures affect energy demand

4. Developing econometric models to identify the relationship between technological efficiency, economic behavior and energy savings
5. Developing econometric models for analyzing large datasets with many noisy variables such as the Residential Appliance Saturation Survey
6. Detailed analysis of two major data sources and estimating the developed economic models
7. Exploring the energy efficiency space in order to identify opportunities for additional original data collection
8. Developing additional partnerships with private sector firms, utilities and NGOs to further expand the scope by initiating additional projects and collecting unique experimental data

### **Major Findings:**

*Theoretical insights on split incentives.* The theory developed in the economic models provides several testable implications, which can be tested empirically. They can be summarized as follows:

1. We expect tenants who rent their dwellings and pay for heating or cooling to under-insulate their dwelling relative to those who rent and do not pay for heating or cooling.
2. We expect tenants who do not pay for their heating or cooling to put in less effort to reduce their heating and cooling use relative to those who pay for their heating or cooling. This can come about through changing of heating or cooling settings more often, higher temperatures when heating, and lower temperatures when cooling. This is also expected regardless of whether the tenant owns or rents the dwelling.
3. We expect tenants who own their dwelling and do not pay for their heating or cooling to under-insulate their dwelling relative to those who own and pay for their heating or cooling.

*Empirical insights on split incentives.* I find that there is limited evidence that tenants who do not pay for heating keep their heat at a higher setting, but strong evidence that tenants who do not pay for heating change their heating setting much less often than those who pay for heating. For example, those who pay for heating are 13% more likely to turn down their heat at night. We interpret our pay for heating results as suggesting that those who are paying for heating are also thinking much more about their heating bill and putting in more effort to reduce their heating bill. The same split incentive issue also appears to hold for central air conditioning, although slightly less strongly. There is also a clear mapping between the theoretical and empirical results on a split incentive issue relating to ownership of the dwelling and the degree to which the dwelling is insulated. For example, if the dwelling is owned by the occupant, the attic/ceiling is roughly 20% more likely to be well insulated, and the exterior walls are roughly 13% more likely to be well insulated. The theoretical results also appear to match the theoretical prediction, where those who pay for heating are slightly less likely to have exterior walls well-insulated.

*Data insights.* I have conducted an in-depth statistical analysis of the EIA-RECS database and documented severe oversights in data collection. In conjunction with the data randomizations introduced by the EIA to protect respondents privacy it was not possible to conduct scientifically valid research on the public use data. I am currently involved in a project in conjunction with the US Bureau of Economic Analysis to access the government use data files and use the private information to continue this research.

*Additional research.* I have also conducted research aimed at understanding the use of carbon offsets by residential consumers. It is often not possible for consumers to purchase new appliances or engage in expensive home retrofit decisions. In such cases, carbon offsets have been marketed by utility companies as a way of offsetting the households' carbon footprint. My research however shows that carbon offsets act as a "indulgences" and in fact lead to an increase in electricity consumption on the months after purchase.

**2. How have the results from this project contributed to the solution of energy efficiency challenges? How is it likely to contribute to solutions in the future?**

*Policy Implications.* Suppose that we could completely correct these split incentive issues. There would be some energy savings from individuals turning down their heating at particular times of day (e.g., night) and putting in effort to change their heating and central cooling settings when they leave the house. Similarly, there would be some energy savings from increased insulation. Quantifying these split incentive issues in terms of energy savings is not trivial, since they depend on a variety of factors, such as the temperature outside, the glazing of the windows, and the efficiency of the heating or cooling system. But importantly, the number of households affected by the pay for heating/cooling split incentive issues are relatively small: less than 3% for heating, and less than 30% for central cooling who live in a sufficiently warm climate. Putting these numbers in light of the results shows that the split incentive issues do lead to a behavioral change suggests that the potential energy savings from alleviating this split incentive issue are unlikely to be dramatic relative to total household energy usage.

The insulation split incentive issue may have potential for somewhat larger energy savings. Roughly a fifth of the sampled population may face a split incentive issue relating to insulation, and the probability of additional insulation for homes that are owned is substantial. Quantifying the energy savings from the additional insulation is perhaps even more difficult in this study, due to the coarseness of the variables included in the survey. Of course, given that only a fifth of the population may be subject to this principal-agent problem and a 13-20% increase in the probability of a well-insulated dwelling, we again would not expect to see energy savings that are dramatic relative to total household energy usage.

These observations may suggest that the energy savings from reducing the split incentive issues may not be large, but do not speak to the economic efficiency implications of targeted policies to induce some of these energy savings. Moreover, our results indicating that split incentives do affect the behavior of landlords and tenants suggests that there may be economic efficiency improving policies to adjust these behavioral responses.

For instance, since these principal-agent problems inherently involve asymmetric information, information programs may be a cost-effective approach to inducing some of these energy savings. Providing feedback on electricity use to households that do not pay for heat may make their energy consumption more salient, and they may be motivated by environmental concerns to exert more effort to save energy. Minimum standards on new rental units may cost-effectively help to address the insulation split-incentive issue.

Additionally, this grant has generated a number of new projects to be developed in the future which aim to quantify the incentive problems as well as economic and behavioral constraints faced by households making energy efficiency decisions using a number of field experiments and thus be able to measure the desired effects with improved accuracy and external validity.

**3. What undergraduate or graduate students, as well as Post-Doctoral fellows, were involved this project. How were they involved? Please list their name, classification and a short description of their involvement.**

Kenneth Gillingham, graduate student, modeling split incentives

Marcel Priebsch, graduate student, data analysis

Kester Tong, graduate student, data analysis

Krishnan Nair Kesavan, post-doc, econometric modeling

Additionally, the project has benefited from research support by a number of undergraduate students who helped download and clean the data and conduct research on energy sector related information: Hojune Choi, Jeremy Shapiro, Marco Beltran, Efsthios Georgoudis, Shengxi Wu and Rusi Yan.

**4. Will you be continuing work on this project? How and with whom? Please include any comments.**

Publicly available data is incomplete in two important dimensions. First, it does not allow us to identify idiosyncratic effects in the absence of repeated observations of household energy use for the same household. Second, many of the important drivers of energy efficiency are not available in public use data.

I am currently working on addressing these two important issues through two collaborations. One collaboration, joint with a colleague from the Bureau of Economic Analysis, will access the private use RECS data files. The second collaboration with an environmental NGO will construct a detailed survey of the motivations and incentives for energy efficiency of residential consumers.

**5. Are you seeking or have you received additional funding as a result of this project, or for continued work on this project? Please list the amount you are seeking/have received, source of the additional funding and a short description.**

The continued work on these questions has received additional funds from an IRISS Seed grant (\$10k).

**6. Has this project generated any other projects? Please describe.**

This project has helped initiate a number of related projects aimed at disentangling the economic and behavioral motivations driving energy efficiency.

- A field experiment on the extent to which “green identity” shapes home retrofit decisions
- An analysis of the confidential RECS survey
- Implementing a survey of attitudes towards energy efficiency among low-income households.

**7. What patents, if any, have you received or applied for?**

N/A

**8. Please list all academic and non-academic (Op-Eds, news magazines, etc) publications and conference presentations as well as articles in progress that came about as a result of this project. May we post these on the PEEC website? If so, please list the URL or provide a pdf version.**

“Split Incentives in Residential Energy Consumption”, joint with K. Gillingham and D. Rapson. Pdf attached.

**9. Provide a URL address for any websites that provide more information for interested parties on your research project, including photos and videos. We will add this information to your project summary on the PEEC website.**

N/A

**10. Have you developed any specific products, (such as databases, physical collections, educational aids, software, etc), as a result of this project? If so, please list along with a short description.**

I developed several large, ready-to-use, clean databases for use in econometric analysis:

- A database based on the RECS data files using repeated cross-sections
- Improved the RASS database with additional covariates such as electricity and gas prices
- Collected a detailed ISO node-level energy use database

**11. Were any undergraduate or graduate courses generated as a result of this project? *If so, please list the course title and a short description.***

I am currently developing a graduate level Environmental Economics course, which will be offered in the Economics department in Winter 2011. The course will address among other topics the behavioral aspects of energy efficiency.

**12. Have you provided any information regarding your research to any public or private institutions (e.g., legislative briefing, government panel, congressional testimony, corporate presentation) or any public or private institution asked you for information regarding your research? *If so, please list the organization, date and a short description.***

N/A

**13. Have you partnered or worked with businesses, governmental agencies, NGOs, or other public or private organizations in connection with your project? *If so, what role have they played? Please list the institutional name, type of institution and a short description of the partnership.***

N/A

**14. What public education activities have you undertaken in conjunction with this project?**

N/A