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Homeowner Views on Housing Market Valuation of Energy Efficiency: An Empirical Investigation

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Homeowner Views on Housing Market Valuation of Energy Efficiency: An Empirical Investigation

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This paper investigates the relationship between energy efficiency and owner reported home value using American Housing Survey data. A hedonic price model is developed in order to isolate the impact of home energy use on the owner's perceived market value of the home. In order to limit the impact of fixed housing characteristics on the model, the fixed effect regression technique is used. Empirical estimation provides evidence that homeowners feel the housing market assigns very limited value to the energy efficiency of their homes.

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I. INTRODUCTION

Citizens and governments are increasingly aware of the importance of reducing carbon emissions. One way of achieving this goal is through investment in residential energy efficiency. The willingness of homeowners to make such investments depends in part on the rate at which they believe the housing market capitalizes energy savings into the resale value of homes. The purpose of this paper is to quantify the value, if any, that homeowners feel the housing market assigns to energy efficiency; this is accomplished through the inclusion of energy use in a hedonic house price model. Further, this paper will examine demographic effects that could lead to variations in the perceived housing market valuation of energy efficiency. American Housing Survey data will be used to estimate the impact of current energy expenditures on the value homeowners feel the housing market assigns to their homes. Although several studies of these issues exist, all of them are weakened by econometric problems this study attempts to overcome.

Homeowners recover the cost of a rational efficiency investment through reduced energy expenditures while they own a home, and through enhanced value when the home is sold. If homeowners believe that future energy savings are highly discounted by real estate markets, they will tend to under invest in energy efficiency improvements. If it is possible to identify those who are prone to this belief, policy makers can be better prepared to elicit more energy conservation investment in the residential housing market.

Implicit Discount Rates

Upgrades or improvements that enhance the energy efficiency of new or existing homes can be viewed as investments that carry a return in the form of reduced energy expenditures. Investment (I) yields a stream of future savings, with S_n representing reduction in energy expenditure in year n.

$$\left(S_{1,}S_2, S_3, \ldots\ldots S_n\right)$$

Normally, one would calculate the present value of future savings as follows, where r represents the discount rate homeowners apply to future energy savings.

Equation I.I: $$\boldsymbol{PV_{no\ resale} = \frac{S_1}{(1+r)} + \frac{S_2}{(1+r)^2} + \frac{S_3}{(1+r)^3} + \ \ldots + \frac{S_n}{(1+r)^n}}$$

If PV > I, i.e., the net present value of the investment is positive, the investment will be made.

However, in most cases, homeowners do not own a house long enough to realize the entire stream of future savings. As a result, they need to capture an additional return on their investment through enhanced resale value. Let $\Delta\ V^*$ represent the change in home value attributed to the energy efficiency investment if a home is sold in year *j.*

Equation I.II: $$\boldsymbol{PV_{resale} = \frac{S_1}{(1+r)} + \frac{S_2}{(1+r)^2} + \frac{S_3}{(1+r)^3} + \ \ldots\ + \frac{S_j}{(1+r)^j} + \frac{\Delta V^*}{(1+r)^j}}$$

ΔV^* can be taken as a measure of the present value of the annual energy savings remaining after the time of sale and capitalized into the value of the home, discounted at some rate r*, which is implicitly applied in the market for existing homes; r* is not necessarily equal to r. If r* is greater than r, PV_{resale} will be less than

$PV_{no\ resale}$; the net present value of the efficiency investment will therefore be less if the home is resold and the incentive to undertake the investment will be correspondingly lower. Since the housing market discount rate r* is unobserved by the home builder or owner, individual perceptions of this discount rate are of key importance to the investment decision.

The future stream of energy savings described above is unobservable. What can be observed is current energy expenditure and owner-reported home value as provided by the American Housing Survey. As the value that homeowners feel the housing market places on energy savings falls, the rate at which they believe those savings are implicitly being discounted rises. To approximate this rate of discount, it is necessary to assume the savings are expected to persist over a long period of time. Given this assumption, the rate at which the market implicitly discounts efficiency investments equals $1/d\Delta V^*$, where $d\Delta V^*$ is the additional value of a home associated with a one dollar reduction in the home's energy cost. As described in Chapter 3, $d\Delta V^*$ will be quantified econometrically in this study.

Research Objectives and Justification

The objective of this paper is to quantify, using appropriate econometric methodology, the relationship between energy use and owner perceived housing prices. While many attempts have been made to isolate the impact of energy efficiency on housing prices, there has been no definitive consensus on the appropriate econometric methodology for conducting these studies. Previous studies utilize data sets that are quite different in nature, making it difficult to compare results across studies. A study by Nevin and Watson (1998) uses American Housing Survey Data to approach this subject and provides a starting point for this research. Through the use of panel data techniques and more recent AHS data, this paper will seek to provide an improved measure of the relationship between energy costs and housing prices. In a global context this research is important, because home energy efficiency stands to become an important player in the reduction of worldwide carbon emissions. Any insight into how homeowners feel the housing market capitalizes the energy efficiency of their homes can help to better prepare policymakers to promote the benefits of energy efficiency.

Home Energy Efficiency and the Reduction of Carbon Emissions

In both national and global contexts, most scientists, politicians, and citizens accept the occurrence of global warming. The Intergovernmental Panel on Climate Change states that the primary cause of climate change comes from human activity, primarily the emissions of CO_2 and other greenhouse gases (Berenstein, 2007). Greenhouse gases are emitted in significant amounts through the production and use of energy. Following in the footsteps of other nations, the U.S. is approaching the implementation of new policies that will place a cap on carbon emissions. However, the specific nature of this carbon emission reduction strategy is still very much in debate. One example of such policy, a carbon emission cap and trade system has been proposed that could reduce carbon emissions 66% by 2050 (Zabarenko, 2008).

In order to assess the economic realities of such policies, several models predicting the economic costs of a carbon emission cap and trade system are available. These models generally predict a reduction in GDP growth with the implementation of a cap and trade system, but few take into account the implicit benefits of the system, and most models conclude that robust growth will still be possible for the U.S. economy under any strategy (Pew Center on Global Climate Change, 2008).

In the last year, climate change studies have been released that detail various possible courses of action to limit greenhouse gas emissions. A report written by McKinsey and Company (2007), in particular, found immense potential for low or negative marginal cost reductions in carbon emissions at the national level. According to the study, rising population will result in the expansion of America's building and transportation industries; this infrastructure expansion, along with the planned use of new coal fired power plants, will lead to a 35% increase in U.S. emissions by 2030 if no action is taken.

The McKinsey and Company report identifies several strategies, each requiring different levels of national effort, to reverse the upward trend in emissions. Figure I.I illustrates the marginal cost curve for a mid-level carbon abatement strategy. As shown in the figure, about 40% of the emissions reductions achieved by this strategy can be implemented at negative marginal cost. In other words, the potential exists for many carbon emission reduction investments to earn positive economic returns in the long run. Energy efficiency improvements in buildings and appliances are atop the list of potential projects that can earn positive economic returns (McKinsey and

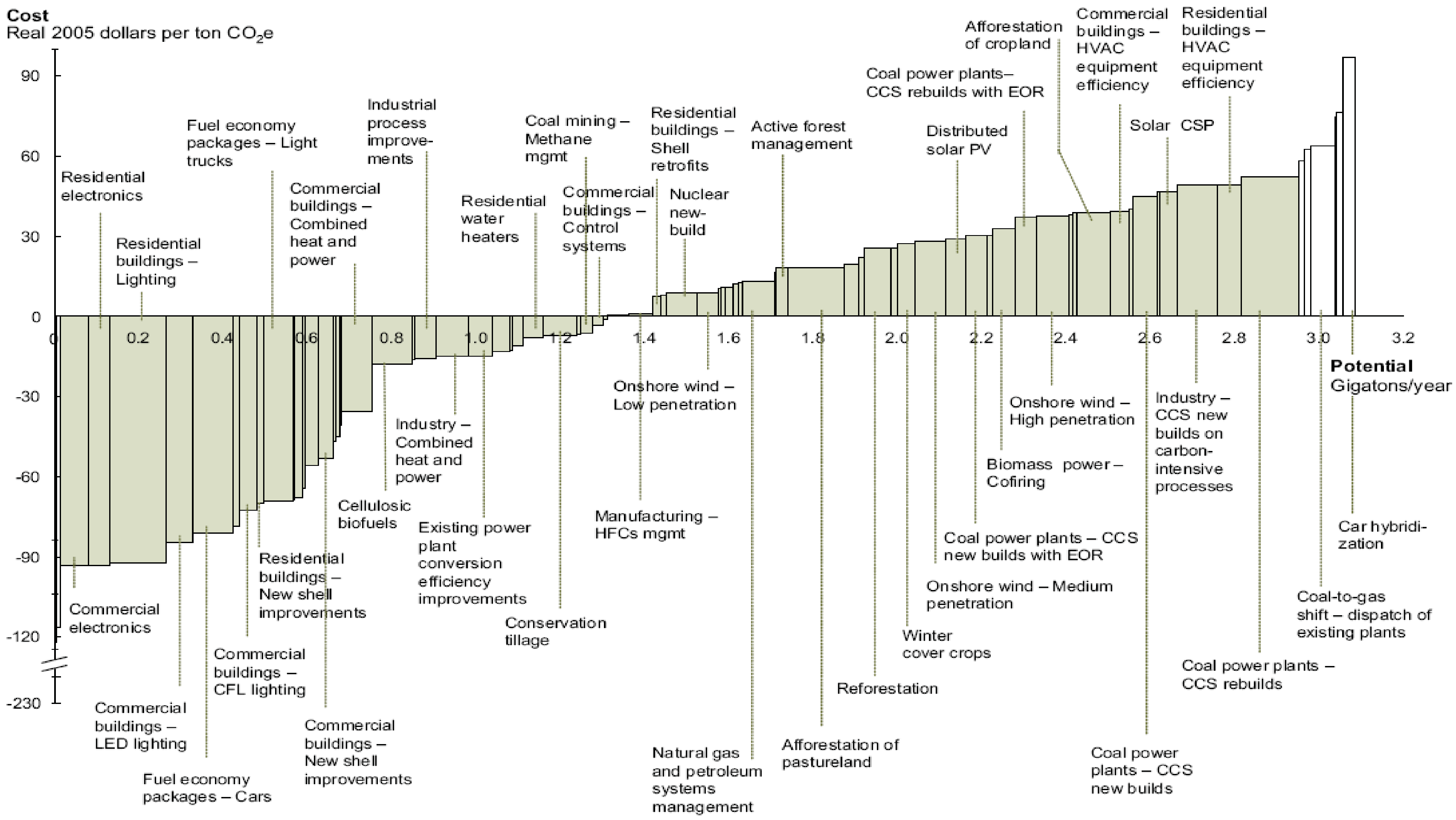
Company, 2007). In 2006, residential energy use in the U.S. accounted for 1,204 million metric tons of CO_2 emissions (Energy Information Administration, 2008).

At a state level, Montana Governor Brian Schweitzer appointed a Climate Change Advisory Committee to conduct a comprehensive analysis of the state's carbon emissions in 2006 (Montana Climate Change Advisory Comittee, 2007). The commission reported that Montana's greenhouse gas emissions have increased 14% since 1990, and identified a variety of measures that can be taken to reduce Montana's carbon emissions back to 1990 levels. Among the measures are several like those in the McKinsey and Company report that involve negative cost investments in increased residential energy efficiency. In addition, the Montana Department of Environmental Quality states that residential energy use accounts for 25% of demand side greenhouse gas emissions, amounting to almost 4 million metric tons of CO2 each year (2008).

These reports are important to this paper because they suggest that people are not taking advantage of high return energy efficiency investment opportunities. The reports also demonstrate that carbon reduction will be an important part of the future for America's economy. Many carbon emission reduction investments could significantly reduce emissions as well as be profitable to investors. Improvements in residential energy efficiency are identified a number of times as investments with immense potential; however, the wide scale implementation of home energy efficiency could be significantly hindered by misconceived homeowner perceptions.

This paper investigates the following hypothesis: homeowners believe investments to reduce home energy use are excessively discounted by the housing market, which results in underinvestment in energy efficiency. This empirical investigation will play a role in providing important information on homeowner efficiency perceptions that could facilitate the implementation and success of a nationwide carbon emission reduction strategy.

Figure I.I: United States Mid-Range Carbon Abatement Potential
Source: (McKinsey and Company, 2007)



II. LITERATURE REVIEW

Since the late 1970's, a number of studies concerning energy efficiency and its effect on housing prices have been published. In these studies, differing methods of quantifying key energy efficiency variables have led to a fairly broad range of findings. These studies, however different in structure, have been consistent in reporting that energy efficient homes carry a premium in the housing market, *ceteris paribus*. The following table briefly summarizes the principal findings in the literature.

Table II.I: Summary of Related Literature

Study	Time Period	Dependent Variable	Sample Size	Findings
Johnson and Kaserman (1983)	(1978)	Sale Price	1317	Investment yielding a $1 decrease in annual fuel bill will increase home value by $20.73
Longsreth et al. (1984)	(1971-1980)	Sale Price	615	Additional inch of wall or ceiling insulation yields a $528 increase in home value.
Laquatra (1986)	(1980)	Sale Price	144	A1 unit decrease in thermal integrity factor yields $2510 increase in sale price.
Dinan and Miranowski (1989)	(1982)	Sale price	234	$1 decrease in expenditure required to keep home at 65̊f will increase home value by $11.63 in an average heating season.
Horrowitz and Haeri (1990)	(1984-1985)	Sale Price	42	MCS homes sell for approximately $1315 more than non MCS homes.
Nevin and Watson (1998)	(1991-1996)	Owner reported home value	2000-16000	$1 decrease in annual fuel bills leads to a $20 increase in owner reported home value.
Laquatra et al. (2002)	(2002)	Critique of above literature outlining the strengths and weaknesses of each.		

Johnson and Kaserman (1983) combine Multiple Listing Service, census, and utility industry data to develop a data set containing 1,317 observations for use in a hedonic price analysis. In order to research housing market efficiency in capitalizing energy efficiency investments, a model including sale price, location, structural, energy use, and neighborhood variables was developed. The authors recognize that family income is positively correlated with both housing expenditure and utility consumption. This correlation would cause ordinary least squares regressions to be biased and inconsistent if family income is not included as an explanatory variable. As a result, two-stage least squares regression is used to estimate the hedonic model. This analysis results in the conclusion that a one dollar decrease in annual fuel bills caused by an investment in energy saving durable goods (goods that increase efficiency and remain permanently attached to the house) will increase the value of a house by $20.73.

Longsreth, et al. (1984) used the existence of specific home attributes related to energy efficiency and the total amount of natural gas consumed as the basis for a hedonic price analysis. In their study, sales price is assumed to be a function of structural (including energy efficiency), neighborhood, accessibility, and public service characteristics. Two models were estimated, one using the existence of home energy efficiency attributes as the energy efficiency measure, the other using the amount of natural gas used to heat the home during 1973. A mail-in survey of homeowners was used to collect information on the structural characteristics of houses for which natural gas billing information was available from the gas supplier. These data were merged with various government records to create the final data set consisting of 615 detached owner-occupied homes that changed ownership between 1971 and 1980.

The authors estimated their models using two-stage least squares regressions. In the first model, the authors found positive significant coefficients on variables relating to extra inches of wall and ceiling insulation and the existence of wood or vinyl window frames. Interpretation of these variables led to reported home value increases of $528 for an extra inch of wall insulation, $508 for an extra inch of ceiling insulation, and $1,863 for the existence of wood or vinyl window frames. While these results are interesting and show a positive value to energy efficiency, they do not shed much light on implicit discount rates. When considered from the point of view of a retrofit investment, the incremental value of $528 for an additional inch of insulation alone would probably not be enough incentive for a homeowner considering such a project. However, people do in fact incur the additional cost of adding extra insulation to their homes on a fairly regular basis. If these investments are rational, the capitalized value of the anticipated reduction in energy expenditures over time must at least be equal to the cost of the retrofit. This observation serves as evidence of undercapitalization of energy efficiency in the real estate market.

Laquatra (1986) obtained data from a project conducted in Minnesota where 144 energy efficient houses were constructed and sold under the authority of various state government agencies. Individual houses varied in their overall efficiency levels, allowing the author to analyze the effects of energy efficiency on the sale prices of houses in the study. A measure of energy efficiency known as the thermal integrity factor, which is based on energy use per heating degree day, was the key variable in the study. The thermal integrity factor is inversely related to energy use. Using a hedonic price equation similar to Longsreth, et al., Laquatra estimated OLS and WLS regressions and concluded that sales price is positively related to energy efficiency, with a $2510 increase in sales price occurring for every one unit increase in the thermal integrity factor from its mean value. While the thermal integrity factor provides a specific measure of energy efficiency, it does not allow for the calculation of the impact of energy cost savings on home value. The investment required to increase the thermal integrity factor by one unit is unknown, along with the exact amount of energy saved by such an improvement. However, there would be evidence of undercapitalization of energy savings if the cost of an efficiency investment that would increase the thermal integrity factor by one was significantly greater than $2,510 and such investments were routinely being made.

Dinan and Miranowski (1989) used a hedonic price model to estimate the implicit value of energy efficiency to homebuyers. Sales data were obtained from Des Moines Iowa Multiple Listing Service records for a period between 1982 and 1984. A total of 234 single-family detached residences make up the relatively small sample size. These records were merged with utility and city assessor's records, along with census data, to develop the final data set which included housing, neighborhood, and income characteristics. This study was made unique through the creation of a proxy variable for structural energy efficiency. Fuel expenditure data was obtained from the local utility company and internal temperature settings for each home were acquired through a mail survey. The proxy variable for structural energy efficiency was defined as the expenditure needed to maintain a house in the sample at 65° F in an average Des Moines heating season. The proxy variable "reflects variation in structural efficiency levels among sample homes, rather than variation in occupant lifestyles" (p. 66). Dinan and Miranowski fit models to the data using the Box-Cox regression method. They conclude that when all independent variables are at their means, a decrease in the expenditures necessary to maintain a home at 65° F during an average heating season of $1 will lead to an increase in the value of the home of $11.63.

Horowitz and Haeri (1990) were able to construct a data set containing homes sold before and after specific energy efficiency standards were put in place by the city of Tacoma, Washington in 1984. Model Conservation Standards (MCS) are a set of building efficiency criteria proposed to improve energy efficiency in the Pacific Northwest. Cities adopting these standards were required to impose strict efficiency regulations on all new home construction. Only MCS-built homes resold before 1988 were kept in the sample in order to control for a number of factors that affect sale price data between time periods. To be retained in the sample, houses were also required to have been built in new subdivisions, which led to a sample size of 43 units. For a second study, the authors used a larger independent set of 143 MCS built houses. For both samples, similar control groups of 25 houses sold immediately before the adoption of MCS standards were used for energy efficiency comparison. Their regressions led the authors to conclude, *ceteris paribus*, that MCS homes sell for approximately $1,315 more than non-MCS homes. Additionally, homes in the sample that utilized heat pumps were found to have an incremental value of $4,384. While this observation is meaningful, it is difficult to determine the market value of energy cost savings resulting from the implementation of MCS standards. Assuming a discount rate of 7%, the incremental value of an energy efficient home reported above implies yearly energy efficiency savings for MCS homes of only $87. This value could lead to the interpretation that MCS homes do not provide significant energy efficiency improvements over non-MCS homes, or that energy efficient homes are undervalued by the real estate market.

Nevin and Watson (1998) utilized the American Housing Survey in an attempt to model the added value of energy efficient homes in the housing market. The paper is directed toward members of the appraisal industry, arguing the importance and necessity of accurate valuations of energy efficient homes. Data sets were created using AHS national data from 1991, 1993, and 1995 as well as AHS metropolitan data from 1992 to 1996. Data from both surveys was limited to single-family, owner-occupied, detached housing units with reported "adequate condition" and piped gas, electricity or fuel oil for heating. Housing units in reportedly "substandard condition" were not included based on the assumption that these houses often rely on malfunctioning major heating appliances which can limit the accuracy of utility consumption information. Rental units were excluded from the final data set since rental occupants interviewed for the AHS are often not familiar enough with specific unit characteristics to provide accurate responses. A fairly limited range of variables were used, including those pertaining to structural, utility expenditure, and regional characteristics. Two fuel-interaction variables were included to control for relationships between living space and utility expenditure. These variables were used "to isolate the effect of energy efficiency in the coefficient for total annual fuel expenditures. For houses with equal living space, home buyers were expected to pay more for homes with lower fuel bills, but the two interaction variables are included to control for larger homes that have higher utility bills because they have more interior space" (p. 406). The authors estimated regressions for detached and attached homes utilizing each of the three specified types of heating fuel. In all, 45 regressions were calculated leading to estimated increases in home value of about $20 for each dollar reduction in annual fuel bills. Nevin and Watson report that about half of the 45 regressions report a coefficient on the annual fuel bill variable within one standard error of -20. These results have been disputed by Laquatra, et.al., (2002) who assert that Nevin and Watson drastically misinterpret their results. By omitting the effects of the two fuel interaction variables mentioned above in their final analysis, Nevin and Watson overestimated the capitalization of energy efficiency into home values.

Laquatra et al. (2002) provide a critical review of the literature on the subject of energy efficiency and housing prices. Their review exposes some important econometric problems that are inherent throughout the literature. The validity of several studies is hindered by the limited nature of the data utilized. The authors question the validity of studies reported above for the following reasons: The studies conducted by Nevin and Watson (1998) and Horrowitz and Haeri (1990) contain conclusions that cannot be supported by their own analysis. These conclusions are flawed because of mistakes in interpretation of key variables and omission of important statistical tests. Nevin and Watson included interaction terms involving the utility consumption variable that were not taken into account in the coefficient interpretation. This omission caused the final results to be significantly overvalued. Laquatra, et al. recalculated the capitalization rates and came up with a negative value. Results reported by Longsreth (1984) are difficult to apply to the housing market in general because the data source used in the study was obtained from an experiment that created an artificial market environment. Finally, the two-stage least squares analysis reported by Johnson and Kaserman (1983) and Dinan and Miranowski (1989) while sophisticated, omits important information regarding the strength of instruments in intermediate regressions that is necessary to validate their conclusions.

Conclusions made in the literature imply that some energy efficient home investments only marginally increase home value (Longsreth, Coveney, & Bowers, 1984). Two possible reasons for this outcome can be hypothesized. First, it is possible that investments in energy efficiency do not have a large impact on overall energy costs relative to the cost of the investment. Second, it is possible that these energy efficient investments are being discounted at an overly high rate. This paper attempts to correct the econometric problems mentioned above and estimate the discount rate in question.

III. METHODOLOGY AND DATA

Methodology

The following section contains a discussion of the econometric methodology used for empirical estimation in this study. Following the methodology section is a detailed description of the American Housing Survey data and the process by which it was prepared for empirical estimation.

Hedonic Price Function

Following a methodology similar to Johnson and Kaserman (1983) and as outlined by Freeman (1995), a hedonic price model is estimated for the national sample of housing provided by the American Housing Survey.

If the housing market is in equilibrium, the value of home *i* can be modeled as a function of the energy cost (E), structural (S), regional (R), and household (H) characteristics of that home. Energy costs affect the value of a home based on the assumption that homes with lower energy costs are worth more. Household characteristics are used not because they directly affect home value, but because they are considered proxies for otherwise unobserved housing characteristics that affect value.

Equation III.I:

$$\mathbf{Value_i = \beta_0 + \beta_j Energy\ Costs_i + Structural\ Characteristics_i + \gamma_r Regional\ Characteristics_i + \theta_s Household\ Characteristics_i + \mu_i}$$

This equation, a hedonic price function, will be estimated for the national subset of housing units provided by the American Housing Survey.

As explained by Dinan and Miranowski (1989), if a hedonic model is correctly specified,

$$\frac{\partial \mathbf{V}}{\partial \mathbf{C_j}} = \mathbf{V_{C_j}}$$

where V_{C_j} is the change in value (V) that is associated with a one-unit change in the housing characteristic C_j, *ceteris paribus*. This study will examine owner-reported home value change caused by a change in energy expenditure.

<u>Panel Data Methods</u>

The American Housing Survey is a longitudinal, or panel data set. Panel data is organized in such a way that both cross sectional and time series characteristics can be simultaneously analyzed. This is accomplished by observing changes of single units over time for each observation in the data set. Most importantly, panel data can be used in a fashion that eliminates the effect of fixed characteristics (attributes of a house that do not change over time), both observed and unobserved, in the results of regression analysis. Wooldridge (2006) describes the fixed-effects transformation used to eliminate the impact of fixed characteristics. Using a_i and subscripts *i* and *t* to represent a vector of fixed characteristics, housing units, and time periods respectively, the hedonic price model can be written as:

Equation III.II: $$\boldsymbol{y_{it} = \beta_1 x_{it1} + \beta_2 x_{it2} + \ldots + \beta_k x_{itk} + \beta_l a_i + u_{it}, t = 1, 2, \ldots T}$$

Next, each individual unit is averaged over time to create the equation:

Equation III.III: $$\boldsymbol{\bar{y}_i = \beta_1 \bar{x}_i + \beta_2 \bar{x}_i + \ldots + \beta_k \bar{x}_i + \beta_l a_i + \bar{u}_{it}}$$

Subtract the second equation from the first for each t to get:

Equation III.IV: $y_{it} - \bar{y}_i = \boldsymbol{\beta}_1(\mathbf{x}_{\mathbf{it1}} - \bar{x}_{i1}) + \boldsymbol{\beta}_2(\mathbf{x}_{\mathbf{it2}} - \bar{x}_{i2}) + \ldots + \boldsymbol{\beta}_k(\mathbf{x}_{\mathbf{itk}} - \bar{x}_{ik}) + (\boldsymbol{u}_{it} - \bar{\boldsymbol{u}}_{it}), \mathbf{t} = \mathbf{1}, \mathbf{2}, \ldots, \mathbf{T}$

Data of this form is referred to as time-demeaned data. For each unit in the cross section, the average value for that unit is subtracted from the value from each time period. The most important feature of this equation is the absence of the term a_i accounting for fixed housing characteristics. Since these characteristics do not change over time, they are eliminated during the subtraction process. This data is analyzed using pooled OLS, with the estimators derived from time-demeaned data referred to as fixed-effects estimators. For this study, this equation will be estimated using the xtreg, fe command in Stata v.10 which automatically time demeans data and applies the appropriate regression method (Stata, 2007).

Data: The American Housing Survey

The American Housing Survey is conducted by the United States Census Bureau in an effort to maintain current information on the U.S. housing stock. A national sample of 55,000 housing units is surveyed every two years in odd numbered years (ICF International, 2006). The national sample will be used for empirical estimation in this study.

A smaller metropolitan survey consisting of samples of at least 3,200 housing units from 47 metropolitan areas is also taken. In even years, samples are drawn for about 15 metropolitan areas, completing the cycle of the 47 metropolitan areas every six years. Six of the largest metropolitan areas are included with the national sample every four years (US Census Bureau, Census Special Reports, 2004).

The sample is adjusted to account for new home construction, but generally housing units are surveyed in multiple years to track changes in household and structural characteristics over time. Household members representing each housing unit in the sample are interviewed via telephone or personal interview. For many variables, data is based on information regarding the householder, the person owning or renting the home (ICF International, 2006).

The U.S. Census Bureau designs the American Housing Survey in order to provide a representative "cross section" of American housing units (US Census Bureau, Census Special Reports, 2004). The survey micro-data (individual observations for each housing unit), along with extensive housing reports, are available to the public in order to facilitate research on this important part of the American economy. The AHS codebook is a downloadable data guide containing a wealth of information regarding variable definitions, data coding and structure, and recent survey changes (ICF International, 2006).

American Housing Survey data is appropriate for this study for a number of reasons. Most importantly, data is collected on a wide variety of housing characteristics and open access to multiple survey years allows the analysis of trends over time. Data pertaining to general housing-unit characteristics (such as square footage and number of bedrooms), comprehensive utility cost information, and owner reported home values are included in the survey. In addition, data are collected on a variety of topics ranging from individual and household characteristics, to neighborhood quality and journey to work information (US Census

Bureau, Census Special Reports 2004). The following sections contain more detailed information on the AHS data to which a hedonic price model will be fitted.

Data Structure

American Housing Survey national data is publically available for the years 1997-2005 via the U.S. Census Bureau HUD User online interface (United States Census Bureau, 2001-2007). Prior survey years are also accessible from several sources, but are not readily available for download. Significant structural changes were made in 1997 that computerized all aspects of the survey in order to facilitate data collection and reduce errors. As a result of this change, the AHS codebook applies only to the years 1997-2005 and data sets for those years are similar in structure (ICF International, 2006).

In the original format that is available for download, American Housing Survey data is organized into eight separate files, with each file containing data on a specific set of housing attributes. Original file names will be used in order to allow for easy reference to the AHS Codebook. The file HOMIMP contains data pertaining to any home remodels or upgrades that have taken place since the last survey. In the JTW file, information on household journey to work is provided. The MORTG file contains mortgage information provided by homeowners. In the NEWHOUSE file, the bulk of household and unit characteristics are presented. OWNER provides data on those who own rental properties. Information on the individuals that make up each household is contained in the PERSON file. Finally, RATIOV and RMOV provide data verification and data on those who have recently moved (ICF International, 2006). Since each of the above files contains information on different housing characteristics, different units of observation are used in some files. These units of observation vary from the individual level to households and housing units. Despite these differences, a unique variable, CONTROL, is present in each file that ties each observation to its respective housing unit. This variable can be used in the creation of a single file that contains information from each of the eight smaller files mentioned above.

For this project, the initial challenge was to create a single data set that contained only the data required for a hedonic house price study. It was also necessary for this data to be in the proper format for analysis with the Stata statistical package (Stata, 2007). Original files were accessed by Stata where thorough data cleanup and merging were conducted. Due to the vast amount of information provided by the American Housing Survey, only data from the NEWHOUSE, HOMIMP, and PERSON files are utilized. Complete Stata command files outlining this process are included in Appendix B.

Sample Selection

In its original state, American Housing Survey data includes many observations that are not appropriate for this type of study. In this section, the specific criteria used in the definition of the final sample are outlined.

American Housing Survey national data is available for the years 1997, 1999, 2002, 2003, and 2005. The original files for each year contain approximately 55,000 observations, many of which are surveyed over multiple years. All data from 1997 was discarded due to several differences in data collection that made merging with data from other years difficult.

The sample used for empirical analysis in this study was limited to single-family, owner-occupied, detached housing units. As described by Nevin and Watson (1998), in order to study the effects of energy efficiency on owner-reported home values, it is important to consider only the portion of housing units in the sample that are occupied by those who are capable of providing accurate, specific data when surveyed. For example, rental tenants may not be individually billed for utility expenses and also may not be able to accurately estimate the value of their residence. Owner/renter status and data on buildings that contain multiple housing units are provided in the American Housing Survey data. Structures containing multiple housing units may be sold under different market conditions and may have significantly different energy use characteristics than detached homes.

Because of the significant impact that inadequate characteristics may have on home value and energy use, only those units that are considered to be in adequate condition were kept in the final sample. Information on housing adequacy is included in the American Housing Survey. A unit is considered inadequate if it has experienced multiple heating equipment breakdowns, does not have electricity or plumbing, or is deficient in several other structural categories (ICF International, 2006).

Housing unit observations for which any variable contained a topcoded value were removed from the sample. Topcodes are used in the public presentation of survey results in order to preserve the anonymity of homeowners. Results that are identified as topcodes, or "extreme outlier values" are adjusted to a preset value for each variable (ICF International, 2006). For example, housing units with owner reported home values of greater than \$350,000 are given a value that is equal to the mean value of all homes with reported values of greater than \$350,000. Therefore, the full range of home values from the original sample is not analyzed. All homes in the final sample used for empirical estimation have estimated values of less than \$350,000 since accurate owner-reported home values are of great importance to this study. The removal of topcoded variables resulted in the elimination of approximately 5,000 observations for each year in the sample. Approximately 4,000 of these observations were removed as a result of topcoded owner-reported home values.

Finally, individual year datasets were merged into one balanced set of panel data. Using Stata v.10, data were merged based on the value of the control variable, which contains a unique value for each housing unit regardless of survey year. Only those housing units that are present in all four survey years were kept for the final dataset. To investigate the effect of household characteristics on householder perception of the market valuation of energy efficiency, the sample was segmented into sub-samples based on education and income.

Variable Selection

This section is a discussion of variables from the American Housing Survey that will be included in the regression model.

Owner-Reported Home Value

The dependent variable in the regression analysis is owner-reported home value as provided in response to the question, "What is the current market value of the unit?" (ICF International, 2006). While actual market sales data might be preferable to owner estimates, Kiel and Zabel (1999) show that American Housing Survey owner- reported home values are appropriate for the creation of housing price indices and also provide accurate estimates of the value of housing and neighborhood characteristics. These values have been shown to be consistently about 5% higher than actual sale prices (Kiel & Zabel, 1999). Since there is consistency in this upward bias, regression analysis will not be affected.

Owner reported home values provide insight into how homeowners value the efficiency characteristics of their homes after those homes are purchased. Homeowner investment decisions and their respective rates of return are also determined by the homeowner's perceived value of those investments. These observations lead to the conclusion that owner estimates of unit value are appropriate for this study.

Structural Variables

The value of a house is dependent upon a number of structural features of the house, and the presence or absence of permanently installed appliances. A variety of structural variables describing such features are available in the AHS data.

Although it may seem that many structural features of a house are fixed and therefore do not need to be accounted for in the fixed effects model employed here, in fact home remodels occurring during the sample period can change these structural features over time. Such changes in these features are reported for many homes in the AHS sample although some of these changes may be attributable to reporting error. The number of homes reporting variations between 1999 and 2005 in the number of bedrooms, bathrooms, and floors, and in the presence or absence of a basement are listed in Table III.I.

Table III.I Changes in Structural Variables

Variable	Number of Changes between 1999 & 2005	Total Observations
Bedrooms	2,616	24,236
Bathrooms	2,099	
Floors	451	
Basement	86	

A large number of homes in the sample reported changes in numbers of bedrooms and bathrooms between 1999 and 2005. Given that these changes can be accomplished fairly easily by remodels and room reclassifications, it is assumed that the reported changes are not the result of reporting error and numbers of bedrooms and bathrooms were included in the model. On the other hand, given the difficulty of adding additional floors and basements to a home, variables describing these characteristics were excluded from the regression equation based on the assumption that the majority of the variation is due to reporting error.

Data on recent home upgrades is available in the AHS data. This data is categorized to represent many types of home upgrades, with several categories representing upgrades that can impact the energy use of a home. Upgrades involving the replacement of windows/doors or insulation were deemed to have an impact on the value of a home. These upgrades are isolated in a single variable, which contains the number of efficiency upgrades conducted between 1999 and 2005 for each unit in the sample.

Several variables representing the presence/absence of certain appliances are included in the model based on the assumption that such appliances are considered permanently installed features of a house that affect its value, but that can vary over time. Specifically, four dummy variables defining the presence in the unit of central air conditioning, a dishwasher, a garbage disposal, and a trash compactor were included in the analysis.

Energy Cost Variables

For this study, the energy efficiency of a house is modeled by the monthly cost of electricity, gas and fuel oil. These expenditures are important because of the assumption that, other things equal, homes with higher energy use are less energy efficient than those with lower energy use. While most energy use can be attributed to the inherent characteristics of a house, there is some behavioral variation in utility use between houses which introduces a degree of error to efficiency estimation. Some variation in energy use is also attributable to the presence or absence of certain appliances, but it is assumed that appliances are an integral, installed feature of the house, and their energy use is considered to be inherent to the house itself.

Regional and Household Variables

While regional characteristics certainly impact home value, they are not included in the fixed-effect hedonic price regression specification. This is because such characteristics are fixed and their effects are eliminated with the use of the fixed-effect regression model.

The only household variable included in the regression specification is a measure of household income. It is assumed that those with higher incomes tend to live in homes with, other things equal, certain unobserved amenities that increase the home's value. The income variable used here is "the sum of the wage and salary income of the householder and all related individuals age 14+ and all other reported income or loss (ICF International, 2006)".

The econometric methods used in this analysis are intended to overcome two problems commonly encountered in attempts to measure the impact of energy efficiency on house prices. As a result of data limitations, many studies have not been able to control for variations in homeowner income across housing unit observations. Also, unobserved fixed characteristics make it difficult to correctly specify a hedonic price model.

While homeowner income does not impact the characteristics of a house directly, it can be considered a proxy for certain luxury features that tend to give a house higher value, and are often energy intensive. The assumption is made that households with high incomes tend to utilize or demand these features in their homes, and can afford to use more energy as a result of their income. Therefore, if income (and implicitly the presence of luxury features) is not controlled for, the energy efficiency variable will capture their effect and confound the measurement of the effect of energy efficiency on home value. In the absence of income data, the effect is captured in the error term. This biases OLS estimates of the coefficient on utility bill because income is likely to be correlated with utility bills. Fortunately, this problem can be overcome using American Housing Survey data, which include a measure of the income of housing unit occupants. Names and definitions are reported in Table III.II for all variables included in the hedonic price model.

Table III.II Variable Names and Definitions

Variable	Definition
Value	Current market value of unit (owner estimate)
Amte	Average monthly cost of electricity
Amtg	Average monthly cost of gas
Amto	Annual cost of fuel oil
Upgrade	Number of upgrades
Bedrms	Number of bedrooms in unit
Baths	Number of bathrooms in unit
Airsys	Central air conditioning
Dish	Unit has a working dishwasher
Disposal	Unit has a working garbage disposal
Fireplace	Unit has working fireplace
TrashComp	Trash compactor dummy
1999	1999 year dummy
2001	2001 year dummy
2003	2003 year dummy
2005	2005 year dummy
FamIncome	Family income

Descriptive Statistics and Regression Model Specification

Tables III.II and III.III report descriptive statistics and means by year for all variables used in regression equations. Equations III.V and III.VI detail the regression specifications for the full and small models reported in table IV.I.

Equation III.V: Full Model Specification: $Value_{it} = \beta_1 Amte_{it1} + \beta_2 Amtg_{it2} + B_3 Amto_{it3} + \beta_4 Upgrade_{it4} + \beta_5 Bedrms_{it5} + \beta_6 Baths_{it6} + \beta_7 Airsys_{it7} + \beta_8 Dish_{it8} + \beta_9 Disposal_{it9} + \beta_{10} Fireplace_{it10} + \beta_{11} TrashComp_{it11} + \beta_{12} Year\_99_{it12} + \beta_{13} Year\_01_{it13} + \beta_{14} Year\_03_{it14} + \beta_{15} Year\_05_{it15} + \beta_{16} FamIncome_{it16}$

Table III.III: Descriptive Statistics for Full Panel Data Set

	Mean	Std.dev.	Min.	Max.
Owner-Reported Home Value	129649.71	67016.53	10000.0	350000.0
Monthly Electricity Bill	73.97	39.52	2.0	251.0
Monthly Gas Bill	46.36	44.39	0.0	278.0
Monthly Fuel Oil Bill	8.50	28.69	0.0	339.4
Central A/C Dummy	0.68	0.47	0.0	1.0
Number of Upgrades	0.30	0.55	0.0	4.0
Dishwasher Dummy	0.67	0.47	0.0	1.0
Garbage Disposal Dummy	0.47	0.50	0.0	1.0
Fireplace Dummy	0.43	0.50	0.0	1.0
Trash Compactor Dummy	0.03	0.17	0.0	1.0
1999	0.25	0.43	0.0	1.0
2001	0.25	0.43	0.0	1.0
2003	0.25	0.43	0.0	1.0
2005	0.25	0.43	0.0	1.0
Family Income	61151.34	60393.57	-14765.0	943518.0
N				

Table III.IV: Variable Means by Year

	2005	2003	2001	1999
Owner-Reported Home Value	153482.52	133372.84	120707.91	111035.58
Monthly Electricity Bill	74.33	74.69	71.76	75.11
Monthly Gas Bill	54.75	45.33	49.58	35.78
Monthly Fuel Oil Bill	10.19	8.57	8.51	6.74
Central A/C Dummy	0.71	0.69	0.68	0.65
Number of Upgrades	0.47	0.35	0.24	0.12
Dishwasher Dummy	0.69	0.68	0.67	0.66
Garbage Disposal Dummy	0.48	0.48	0.47	0.46
Fireplace Dummy	0.43	0.43	0.43	0.43
Trash Compactor Dummy	0.03	0.03	0.03	0.03
1999	0.00	0.00	0.00	1.00
2001	0.00	0.00	1.00	0.00
2003	0.00	1.00	0.00	0.00
2005	1.00	0.00	0.00	0.00
Family Income	59936.63	63922.38	63608.78	57137.55
N	6059	6059	6059	6059

Equation III.VI: Small Model Specification: $Value_{it} = \beta_1 E\_Bill_{it1} + \beta_2 G\_Bill_{it2} + B_3 O\_Bill_{it3} + \beta_4 Upgrade_{it4} + \beta_5 Bedrms_{it5} + \beta_6 Baths_{it6} + \beta_6 Year\_99_{it6} + \beta_7 Year\_01_{it7} + \beta_8 Year\_03_{it8} + \beta_9 Year\_05_{it9} + \beta_{10} FamIncome_{it10}$

IV. EMPIRICAL ESTIMATION

Following the general outline described above, the fixed-effects regression procedure using panel data is used to estimate the coefficients of the hedonic price function. A model containing all variables listed in Table III.I is included, along with a second, smaller model that does not include appliance variables from the full regression. Results of this smaller model differ only slightly from the full model, indicating robustness to changes in specification. Several models are estimated using demographically-segmented data in order to isolate the possible impact of demographic differences on estimation results. Results from the smaller equation will be referred to in the discussion of empirical estimation results, as well as comparison with the segmented regressions.

Results and Discussion for Full Sample

Estimation results for the full and small specifications of the fixed-effect model are reported in table IV.I.

In terms of goodness of fit, the small model has an R^2 within of .214, meaning that 21% of the variation in the dependent variable can be attributed to the model. An F-test of all variables in the regression specification rejected the null hypothesis that none of the variables are associated with the dependent variable, with an F of 331.26 and a p-value of <.001. An F-test of the fixed effects rejected the null hypothesis that all house fixed effects are equal to zero with an F of 7.68 and a p-value of <.001. This implies that the fixed-effects model is more appropriate than a model that does not account for fixed effects. The random-effects model was also tested against the fixed-effects model with a Hausman statistic of 710.169 and a p-value of <.001. This implies that the fixed-effect model was shown to be appropriate for this study. Regression results were analyzed with clustered standard errors, and similar results to the original specification were found which indicates that heteroskedasticity is not a concern.

Homeowners who undertook energy efficiency upgrades as described above attributed $3,253.50 of additional value to their homes for each separate upgrade conducted, *ceteris paribus*.

Table IV.I: Fixed Effect Regression Results for Full and Small Models

	Small Model	(t)	Full Model	(t)
Monthly Electricity Bill	15.0	(1.44)	14.1	(1.48)
Monthly Gas Bill	-19.3*	(-1.76)	-19.5*	(-1.91)
Monthly Fuel Oil Bill	86.9**	(3.70)	86.0**	(4.71)
Number of Upgrades	3253.5**	(3.22)	3077.5**	(3.49)
Number of Bedrooms	6118.3**	(6.31)	6019.6**	(7.29)
Number of Bathrooms	5473.9**	(4.42)	5301.8**	(5.26)
2001	9122.3**	(17.39)	9000.0**	(13.25)
2003	21199.9**	(32.08)	21035.4**	(30.24)
2005	41053.8**	(44.96)	40826.2**	(54.02)
Family Income	0.03**	(5.19)	0.03**	(5.90)
Central A/C Dummy			1788.6	(1.08)
Dishwasher Dummy			3906.2**	(2.17)
Garbage Disposal Dummy			4112.0**	(1.96)
Fireplace Dummy			3576.6**	(2.71)
Trash Compactor Dummy			-2951.5	(-0.81)
Constant	80286.8**	(21.86)	73919.8**	(21.65)
N	24236		24236	
R-square	0.214		0.215	
Adjusted R-square	0.214		-0.0477	
F	316.6**		331.3**	
p-value	0.00		0.00	

t statistics in parentheses

* p<.1, ** p<0.05

Family income is shown to be positively correlated to owner-reported home value, although the value of the coefficient is quite small at .03. For all models, owner-reported home value is significant and positively correlated to the year in which the value was reported. Using 1999 as a base case, coefficients on dummy variables for the years 2001, 2003, and 2005 have values of: 9,122.3, 21,199.9, and 41,053.8. These values are not surprising due to nationwide increases in home value that took place during the sample time period.

Monthly fuel oil bills are positively related to perceived home value with a $1 increase in monthly fuel bill corresponding to an $86.90 increase in home value. Coefficients on the fuel oil variable are consistently positive and significant throughout the analyses reported in this paper. While the direct relationship between fuel oil expenditures and house value is puzzling, fuel oil use is relatively uncommon among homes in the sample used here (about 10% of homes use fuel oil). It was originally considered that these homes may embody some other unique characteristics that are captured by the fuel oil variable and confound the estimation of accurate coefficients, perhaps a regional characteristic since most homes that use fuel oil are located in the U.S. northeast. However, regression results from a model including only those homes heated by fuel oil still show a positive and statistically significant coefficient for the fuel oil variable. This result confounds all past assumptions on the nature of the fuel oil variable, and the assumption is made that the result is an anomaly.

The coefficient on the gas bill variable is negative and significant at the 10% error level; for every $1 increase in monthly gas expenditure, owner-reported home value falls by $19.30, *ceteris paribus*. Annually, a $100 increase in gas expenditure is associated with a decrease in owner-reported home value of $160.83, *ceteris paribus*. Typically, gas plays a limited, but important role in the everyday functioning of a household. Gas is primarily a heating fuel, but it is also used in some cases to heat water, for cooking, air conditioning, and clothes drying. About 65% of the homes in the sample use gas as their primary heating fuel. While there are certainly some exceptions, the uses mentioned above generally describe the extent to which gas is used. The majority of these uses are significantly impacted by the overall efficiency level of a home in terms of thermal integrity and appliance efficiency.

The coefficient on monthly electricity bill is positive, but not statistically significant. This result could arise from the general nature of household electricity consumption. Aside from homes that are heated by electricity (about 23% of homes in this sample utilize electricity for heating) monthly electricity bills are generally not dictated by the overall efficiency level of a home. While appliance efficiency does play a part in overall electricity bills, the limitless number of items that can consume electricity in a home can easily override the gains made by appliance and overall home efficiency. In a given housing unit, the existence of appliances or electronics that consume a great deal of electricity can generally be attributed to the personal preferences of the homeowner. Two homes with the exact same set of structural and efficiency characteristics can use vastly different amounts of electricity as a result of preferences that are impossible to model with the techniques used in this study. As a result, the coefficient on electricity use is not surprising.

These estimated energy cost coefficients can be considered evidence that, as a whole, U.S. homeowners feel the housing market places a very small value on the energy efficiency characteristics of their homes. To illustrate the impact of this value, consider the following situation:

A homeowner is considering an investment in the energy efficiency of his/her home that will yield a $100 decrease in annual gas expenditure for the next 30 years.

Using the present value calculation described in equation I.I, with a discount rate of 5%, the present value of this stream of energy savings is $1,537.25. From an economic standpoint, homeowners with no plans of selling their homes will make this investment if it costs less than $1,537. However, long-term home ownership is not common. If a homeowner plans to sell her home in *j* years, she will only receive the discounted value of energy savings for those years plus the discounted additional value that the market places on the improved efficiency of her home upon resale.

Given the empirical estimation results reported above, the $100 decrease in gas bills provided by the investment will only net, *ceteris paribus*, a $160.83 increase in home value upon resale. If the holding period for the house (j) is ten years, the net present value of the investment is only $870.91 (see Equation I.II).

Household Demographic Characteristics and Perceived Market Valuation

In order to investigate the relationship between the personal characteristics of homeowners and their assessment of the impact of improved energy efficiency on home value, several regressions were estimated based on samples segmented by certain demographics.

In order to evaluate the impact of household income on perceived housing market valuation of fuel savings, the full sample is split into two groups: one for each group above and below the mean family income of $60,000. These results are reported in Table IV.III. Coefficients on structural variables are quite consistent between the two income groups and the full sample. For the sample with family income above the mean value, gas bill and upgrade variables do not have a significant impact. Small and statistically insignificant coefficients of -6.2 and 2033.4 for monthly gas bill and upgrade are calculated for this higher income group.

For the group with family income of below $60,000, the gas variable coefficient is statistically significant and larger than those of the full sample, and the fuel oil coefficient is smaller and statistically significant. Households in the lower income group appear to feel that the housing market places a higher value on homes that use gas efficiently than the sample as a whole, and the high income segment of the sample. For this lower income sample, a one dollar increase in the monthly gas bill yields a $31.40 decrease in owner reported home value, *ceteris paribus*. In terms of annual gas bills, a $50 increase in the annual gas bill yields a $130.50 decrease in owner-reported home value. Each efficiency upgrade conducted during the sample period brings an increase in owner-reported home value of $3355.7 and is statistically significant.

These results are not surprising since those with high incomes are not forced to spend a significant portion of their disposable incomes on home utility expenses and may not consider energy efficiency to be an important characteristic. Homes owned by families with high income may have certain luxury oriented characteristics that impact owner reported home value in ways that override the effect of efficiency.

Table IV.III reports regression results for a sample that is segmented based on householder education level. This is done to examine the effect of householder education on perceived market valuation of energy savings. The full sample is split into two groups, i.e., for home owners whose educational attainment is less than college graduation and college graduation or greater. Structural variable coefficients were similar to those of the full sample in both education categories. As with the income regressions, differences between samples were clear in terms of efficiency variables.

Table IV.II: Fixed Effect Regression Results for Income Segmentation

	Small Model Coefficient	(t)	Income: < $60000 Coefficient	(t)	Income: > $60,000 Coefficient	(t)
Monthly Electricity Bill	15.0	(1.44)	4.8	(0.35)	40.7**	(2.35)
Monthly Gas Bill	-19.3*	(-1.76)	-31.4**	(-2.31)	-6.2	(-0.31)
Monthly Fuel Oil Bill	86.9**	(3.70)	72.1**	(2.15)	103.2**	(2.40)
Number of Upgrades	3253.5**	(3.22)	3355.7**	(2.44)	2033.4	(1.18)
Number of Bedrooms	6118.3**	(6.31)	6312.0**	(4.93)	5086.4**	(2.82)
Number of Bathrooms	5473.9**	(4.42)	4688.6**	(2.73)	5555.5**	(2.66)
2001	9122.3**	(17.39)	7231.5**	(10.15)	12957.4**	(13.03)
2003	21199.9**	(32.08)	16645.6**	(19.12)	28453.1**	(23.38)
2005	41053.8**	(44.96)	34463.0**	(29.10)	51350.1**	(31.24)
Family Income	0.03**	(5.19)	0.03	(0.97)	0.004	(0.44)
Constant	80286.8**	(21.86)	72732.3**	(15.69)	98264.8**	(13.20)
n	24236		14688		9548	
R-square	0.214		0.164		0.289	
Adjusted R-square	0.214		0.163		0.288	
F	316.6**		124.3**		158.4**	
p-value	0.00		0.00		0.00	

t statistics in parentheses

* p<.1, ** p<0.05

Regression results suggest that householders with lower levels of education feel the housing market places a higher value on home energy savings than those with higher education. The coefficient estimate on the upgrade variable in the lower education level sample is 4,268.3, and is statistically significant. For the higher education level sample, the upgrade coefficient is not statistically significant and is equal to 605.4. The gas bill variable for the lower education group has a coefficient of -34.7 which is statistically significant. For the higher education group, gas bill is not statistically significant and has a value of 6.2. For both segments, the fuel oil coefficient is positive and statistically significant.

These results suggest that education level significantly affects a homeowner's belief that efficiency impacts the home's value. At first glance, one might assume that homeowners with higher education share the opinion that energy efficiency positively impacts home value. The empirical results suggest that those with higher education levels do not believe the market values energy efficiency as much as those with lower education levels. However, the fact that those with higher levels of education generally have higher income may be causing this discrepancy. As shown before, those with higher incomes tend to assume that the housing market values the efficiency levels of their homes less.

Table IV.III: Fixed Effect Regression Results for Education Segmentation

	Small Model		No College Diploma		College Diploma or More	
	Coefficient	(t)	Coefficient	(t)	Coefficient	(t)
Monthly Electricity Bill	15.0	(1.44)	9.5	(0.71)	22.9	(1.33)
Monthly Gas Bill	-19.3*	(-1.76)	-34.7**	(-2.46)	6.2	(0.36)
Monthly Fuel Oil Bill	86.9**	(3.70)	62.6**	(2.11)	121.1**	(2.97)
Number of Upgrades	3253.5**	(3.22)	4268.3**	(3.23)	605.4	(0.38)
Number of Bedrooms	6118.3**	(6.31)	6414.0**	(5.38)	5659.9**	(3.18)
Number of Bathrooms	5473.9**	(4.42)	5805.2**	(3.62)	4163.2**	(2.06)
2001	9122.3**	(17.39)	7983.1**	(11.83)	11015.0**	(12.57)
2003	21199.9**	(32.08)	17691.6**	(21.18)	26886.3**	(24.00)
2005	41053.8**	(44.96)	36698.5**	(30.95)	47639.3**	(32.35)
Family Income	0.03**	(5.19)	0.05**	(4.99)	0.02**	(2.04)
Constant	80286.8**	(21.86)	71462.2**	(16.58)	97100.3**	(13.61)
n	24236		15183		9053	
R-square	0.214		0.178		0.269	
Adjusted R-square	0.214		0.178		0.269	
F	316.6**		156.2**		154.9**	
p-value	0.00		0.00		0.00	

t statistics in parentheses

* p<.1, ** p<0.05

V. CONCLUSION

Climate change studies, such as the McKinsey Report and the Montana Climate Change Advisory Council Report, have recognized a vast potential for reduction of carbon emissions. Many of these investments could earn significant positive economic returns, even when no value is attributed to the benefit of reduced carbon emissions. Economists and policy makers need to understand why, if such investment opportunities exist, they are not taken advantage of more aggressively.

Homeowners will play a key role in any carbon reduction strategy. If homeowners do not believe the housing market will adequately capitalize the energy cost savings that efficiency investments will produce, the strategy will be greatly hindered, as people rarely own a home long enough to realize the total value resulting from an efficiency investment.

The analysis in this paper suggests that current homeowner views on the value of energy efficiency do not support the widespread development of a carbon abatement strategy that heavily relies on residential energy efficiency. Regression results imply that, in general, homeowners do not feel the housing market adequately capitalizes the energy efficiency of homes. Significant, negative coefficients on the gas bill variable lead to the conclusion that some consideration is given to energy efficiency when homeowners report the perceived market value of their homes. These findings are important because they serve as evidence that a foundation has been laid for efficiency to become an important aspect of a home's value. Since there is a consensus among climate change panels about the potential for positive returns on efficiency investments, efforts need to be made to educate homeowners regarding this potential. Further research should be conducted that looks into the cause of this discrepancy between homeowners and energy researchers, in order to change perceptions about the value of home energy efficiency.

Significant potential exists for further research in this area of study. American Housing Survey data worked well for this research, but the use of a more detailed data set would have been beneficial. An ideal set of data would begin with a large, regional set of Multiple Listing Survey data that contains sales data from actual market transactions. This data could be supplemented with efficiency data from a few possible sources. First, data from a utility company could be used to accurately model energy use for homes in the sample. Further, if energy audit information were available from enough homes in the original data set, efficiency could be thoroughly modeled. Second, a survey could be used to determine utility use and demographic information, as well as additional energy characteristics of homes in the sample. If data were collected from a specific region, climate and regional housing market differences would be inherently controlled for in the data. The use of such a data set in an empirical analysis could provide additional insight into housing market valuation of energy efficiency.

Future energy policy should aggressively promote demand-related decreases in energy use. While some programs that promote efficiency exist, new policy should further facilitate efficiency investment and focus heavily on educating homeowners about available efficiency assistance. Finally, efficient lifestyle changes and the widespread use of low cost energy saving items such as compact fluorescent light bulbs and programmable thermostats should be promoted through new energy policy.

APPENDIX A: STATA PROGRAM

```
clear
set mem 800m
set more off
cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\AHS data\AHS 2005 Na-
tional"
clear
insheet using tperson.txt

// I simply replaced the names of the text files for each of the raw
datasets
// and saved each data set manually

clear
cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\AHS data\AHS 2003 Na-
tional"
insheet using tperson.txt

cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\AHS data\AHS 2001 Na-
tional"
clear
insheet using tperson.txt

cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\AHS data\AHS 1999 Na-
tional"
clear

*****************************************************************
clear
set mem 800m
set more off
cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\stata dta files
ahs\AHS 2005"
clear
use thomimp.dta

keep control ras rad

//use a loop to eliminate the ' marks from data
foreach i in control ras {
      gen `i'2 = subinstr(`i', `"'"', "", .)
      destring `i'2, replace
}
drop control ras

//rename the variables
rename control2 control
rename ras2 ras

format control %14.0g
// change the format of the control variable to make it display the
full number
gen year = 2003

//generate a year variable
```

```
order control year ras rad
//change the order of the dataset

save bhomimpcl, replace

*********************************************************************
clear
use tjtw.dta
keep control distj

//use a loop to eliminate the ' marks from data
foreach i in control {
      gen `i'2 = subinstr(`i', `"'"', "", .)
      destring `i'2, replace
}
drop control

//rename the variables
rename control2 control

format control %14.0g
// change the format of the control variable to make it display the
full number
gen year = 2005

//generate a year variable

order control year distj
//change the order of the dataset
save bjtwcl, replace

*********************************************************************
clear
use tnewhouse.dta
keep control nunit2 hhage hhgrad access afuel air airsys amte amtg
amto baths bedrms built cellar dfuel dish displ dry floors fplwk ga-
rage hequip hfuel hown lot numair oven per porch pubsew satpol sch
tenure trash type unitsf value wash wfuel usegas degree metro3 region
rooms zadeq zinc zinc2

//use a loop to eliminate the ' marks from data
foreach i in control  nunit2 access afuel airsys dfuel dish displ dry
garage hfuel oven porch pubsew satpol sch tenure trash usegas wash
wfuel degree metro3 region zadeq  {
      gen `i'2 = subinstr(`i', `"'"', "", .)
      destring `i'2, replace
      drop `i'
      rename `i'2 `i'
}

format control %14.0g
// change the format of the control variable to make it display the
full number
gen year = 2005

//generate a year variable

order control year
```

```
//change the order of the dataset

save bnewhousecl, replace

*********************************************************************
//  In this section, I reshape the home improvement data to contain a
variable for
// the completion of a window/door or insulation retrofit.

clear
cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\stata dta files
ahs\AHS 2005"
use bhomimpcl.dta
keep control ras rad
sort control  ras
replace rad =0 if rad ==.
by control: gen rass= 0
replace rass = 45 if ras ==45
replace rass = 49 if ras == 49
replace rass = 72 if ras == 72
drop ras
rename rass ras
drop if ras == 0

by control: gen remodel=_n
reshape wide ras rad,  i(control) j(remodel)

replace rad1 = . if rad1 < 100
replace rad2 = . if rad2 < 100
replace rad3 = . if rad3 < 100

replace ras1 = . if rad1 ==.
replace ras2 = . if rad2 ==.
replace ras3 = . if rad3 ==.


by control: gen rass = 45 if ras1 ==45 | ras2 == 45 | ras3 ==45
by control: gen rass1 = 49 if ras1 ==49 | ras2 == 49 | ras3 ==49
by control: gen rass2 = 72 if ras1 ==72 | ras2 == 72 | ras3 ==72

drop rad1 rad2 rad3 ras1 ras2 ras3
rename rass ras1
rename rass1 ras2
rename rass2 ras3


summ
save rasrad, replace

  ** merge the rasrad data with the bhoushld data
use bnewhousecl.dta
sort control
merge control using rasrad
rename _merge merge1
order control ras1
duplicates report control
save bnewhouserasrad, replace
```

```
*********************************************************************
clear
cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\stata dta files
ahs\AHS 2005"

** In this section, I reshape the bjtwcl data set in order to provide
mean journey
** to work values with only one observation per housing unit.  I then
merge these values
** with the values obtained above
use bjtwcl
sort control distj
by control: gen person = _n
by control: egen meandist=mean(distj)
drop distj
reshape wide meandist , i(control) j(person)
drop meandist2-meandist8
sort control
rename meandist1 distj
save distj, replace

use bnewhouserasrad
sort control
merge control using distj
rename _merge jdistmerge
duplicates report control

save bnewhouserasradjtw,replace

*******************************************************************
//MERGE 3
clear
use bnewhouserasradjtw
sort control
save bnewhouserasradjtw, replace

// create 1 0 dummies out of the ras1 ras2 and ras3 variables
// 1 if the upgrade took place, 0 if not
// 45 corresponds to a window upgrade
// 49 corresponds to an insulation upgrade
replace ras1 = 0 if ras1 ==.
replace ras1 = 1 if ras1 == 45
replace ras2 = 0 if ras2 == .
replace ras2 = 1 if ras2 == 49
replace ras3 = 0 if ras3 == .
replace ras3 = 1 if ras3 == 72

save 2005Merge, replace

************************************************************
clear
cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\stata dta files
ahs\AHS 2005"
use 2005MERGE.dta

// drop access
// drop merge1 distj jdistmerge access
foreach i of varlist ras1-ras3{
```

```
replace `i' = . if `i' == -6
}

foreach i of varlist ras1-ras3{
replace `i' = . if `i' == -7
}

foreach i of varlist ras1-ras3{
replace `i' = . if `i' == -8
}

foreach i of varlist ras1-ras3{
replace `i' = . if `i' == -9
}

foreach i of varlist air airsys dish displ dry porch pubsew satpol
sch fplwk garage oven tenure trash usegas wash{
replace `i' = 0 if `i' == 2
}

by control: gen metro = 0
by control: gen rural = 0
replace metro = 1 if metro3 == 1
replace metro = 1 if metro3 == 2
replace metro = 1 if metro3 == 3

replace rural = 1 if metro3 == 4
replace rural = 1 if metro3 == 5

drop metro3
save 2005MergeCl.dta, replace

**************************************************************
cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\stata dta files
ahs\AHS 2005"
use 2005MERGECL

replace numair = 0 if numair ==.
replace garage = 0 if garage ==.
// convert the year built variable into age of home
by control: gen age = (2005-built)
drop built
rename age built

// Sort out the data by first checking to see if all households who
report a given heating fuel
// also report a monthly bill for that fuel type.  Second, drop all
households that do not report
// a monthly electricity bill. Then drop all households who report
using gas but do not report a
// monthly bill for gas.  Then keep only owner occupied adequate con-
dition detached houses.

by control: gen efuel= .
replace efuel = . if amte == .
replace efuel = 1 if hfuel ==1

by control: gen gfuel=.a
```

```
replace gfuel = . if amtg==.
replace gfuel =1 if hfuel==2

by control: gen ofuel=.
replace ofuel = . if amto==.a
replace ofuel =1 if hfuel ==3


drop if amte == .
drop if usegas ==1 & amtg ==.
keep if tenure == 1
keep if nunit2 == 1
keep if zadeq ==1
replace amto = 0 if amto ==.

drop if value ==.

// convert amount billed for fuel oil to a monthly average
by control: gen amtom = (amto/12)
drop amto
rename amtom amto


order control tenure nunit2 zadeq
// tenure coded 1 for owner of home
// nunit2 coded 1 for one unit building detached from any other
building 2 if single unit attached to
// other building
// zadeq coded 1 for adequate unit

// create a yes/no dummy from the cellar variable
replace cellar = 0 if cellar == 3
replace cellar = 0 if cellar ==4
replace cellar = 0 if cellar ==5
replace cellar = 1 if cellar == 2

// create dummies for the Wfuel Afuel Hfuel Dfuel Variables
tab wfuel, gen (wfuel_)
drop wfuel_5-wfuel_8
replace wfuel_4 =1 if wfuel==4
replace wfuel_4 =1 if wfuel==5
replace wfuel_4 =1 if wfuel==6
replace wfuel_4 =1 if wfuel==7
replace wfuel_4 =1 if wfuel==8
label var wfuel_1 "Water Heater: Electricity"
label var wfuel_2 "Water Heater: Gas"
label var wfuel_3 "Water Heater: Fuel Oil"
label var wfuel_4 "Water Heater: Other"

replace hequip = 4 if hequip > 3
tab hequip, gen (hequip_)
label var hequip_1 "Heat Equip: Forced Air Furnace"
label var hequip_2 "Heat Equip: Steam/Water Radiators"
label var hequip_3 "Heat Equip: Electric Heat Pump"
label var hequip_4 "Other"

replace afuel=4 if afuel ==.
tab afuel, gen (afuel_)
```

```
label var afuel_1 "A/C: Electricity"
label var afuel_2 "A/C: Gas"
label var afuel_3 "A/C: Other"
label var afuel_4 "A/C: N/A"

tab hfuel, gen (hfuel_)
drop hfuel_5-hfuel_9
replace hfuel_4=1 if hfuel==5
replace hfuel_4=1 if hfuel==6
replace hfuel_4=1 if hfuel==7
replace hfuel_4=1 if hfuel==8
replace hfuel_4=1 if hfuel==9
label var hfuel_1 "Heat Fuel: Electricity"
label var hfuel_2 "Heat Fuel: Gas"
label var hfuel_3 "Heat Fuel: Fuel Oil"
label var hfuel_4 "Heat Fuel: Other"

replace hown = 11 if hown ==0
tab hown, gen (hown_)
drop hown_1-hown_3
replace hown_4 =1 if hown==1
replace hown_4 =1 if hown==2
replace hown_4 =1 if hown==3
replace hown_4 =1 if hown==4
label var hown_4 "Below 5"
label var hown_5 "5 Out of 10 Neighborhood Quality"
label var hown_6 "6 Out of 10 Neighborhood Quality"
label var hown_7 "7 Out of 10 Neighborhood Quality"
label var hown_8 "8 Out of 10 Neighborhood Quality"
label var hown_9 "9 Out of 10 Neighborhood Quality"
label var hown_10 "10 Out of 10 Neighborhood Quality"
label var hown_11 "No Neighborhood"

tab region, gen (region_)
label var region_1 "Northeast"
label var region_2 "Midwest"
label var region_3 "South"
label var region_4 "West"

replace dfuel=4 if dfuel ==.
tab dfuel, gen (dfuel_)
label var dfuel_1 "Dryer: Electricity"
label var dfuel_2 "Dryer: Gas"
label var dfuel_3 "Dryer: Other"
label var dfuel_4 "Dryer: N/A"

tab degree, gen (degree_)
label var degree_1 "Climate: Coldest"
label var degree_2 "Climate: Cold"
label var degree_3 "Climate: Cool"
label var degree_4 "Climate: Mild"
label var degree_5 "Climate: Mixed"
label var degree_6 "Climate: Hot"

//drop variables that have been deemed unnecessary
drop tenure nunit2 zadeq oven satpol access  sch usegas ofuel gfuel
efuel air zinc2 hfuel jdistmerge type wfuel afuel  dfuel merge1 hown
```

```
aorder
order control year

label variable year `"Year"'
label variable airsys "Central A/C Dummy"
label variable amte "Monthly Electricity Bill"
label variable amtg "Monthly Gas Bill"
label variable amto "Monthly Fuel Oil Bill"
label variable baths "Number of Bathrooms"
label variable bedrms "Number of Bedrooms"
label variable built "Age of House in Years"
label variable cellar "Basement Dummy"
label variable dish "Dishwasher Dummy"
label variable displ "Garbage Disposal Dummy"
label variable dry "Dryer Dummy"
label variable floors "Number of Floors"
label variable fplwk "Fireplace Dummy"
label variable garage "Garage Dummy"
label variable hequip "Heating Equipment"
label variable lot "Lot Size in Ft^2"
label variable metro "Metro Location Dummy"
label variable numair "Number of Room A/C"
label variable per "Number of Persons Living in House"
label variable porch "Porch Dummy"
label variable pubsew "Public Sewer Dummy"
label variable ras1 "First Efficiency Upgrade Dummy"
label variable ras2 "Second Efficiency Upgrade Dummy"
label variable ras3 "Third Efficiency Upgrade Dummy"
label variable rooms "Number of Rooms"
label variable rural "Rural Location Dummy"
label variable trash "Trash Compactor Dummy"
label variable unitsf "Square Footage of Unit"
label variable value "Owner Reported Home Value"
label variable wash "Washing Machine Dummy"
label variable zinc "Family Income"
label variable hhage "Age of Householder"
label variable hhgrad "Education Level of Householder"


cd  "C:\Users\Caleb Lande\Desktop\thesis\thesis\stata dta files
ahs\Final Datasets"
save 2005FINAL, replace

// Make appropriate changes in order to create individual year sum-
mary statistics

//Drop variables that are unnecessary
drop distj hown* pubsew
drop if value > 350000
drop if value <10000
drop if unitsf > 4500
drop if unitsf < 500
drop if lot > 968000
drop if lot < 1000
drop if amte > 260
keep if amtg<340 | amtg==.
drop if amto > 400
drop if baths >5
```

```
drop if floors >7
replace amtg=0 if amtg ==.

tab hhgrad, gen (hhgrad_)
replace hhgrad_8 =1 if hhgrad_1 ==1 | hhgrad_2==1 | hhgrad_3==1 |
hhgrad_4==1 | hhgrad_5==1 | hhgrad_6 ==1 | hhgrad_7==1
rename hhgrad_8 hhgrad0
label variable hhgrad0 "Education Less: than High School Graduate"
rename hhgrad_9 hhgrad1
label var hhgrad1 "Education: High School Diploma"
rename hhgrad_10 hhgrad2
label var hhgrad2 "Education: Some College"
replace hhgrad_11 =1 if hhgrad_12==1 | hhgrad_13==1
rename hhgrad_11 hhgrad3
label var hhgrad3 "Education: Associates Degree"
rename hhgrad_14 hhgrad4
label var hhgrad4 "Education: Bachelors Degree"
replace hhgrad_15 =1 if hhgrad_16==1 | hhgrad_17==1
rename hhgrad_15 hhgrad5
label var hhgrad5 "Education: Graduate Degree"
drop hhgrad_*


save 2005summary, replace
```

```
// Create a fixed effect model

clear
cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\stata dta files
ahs\final datasets
use 2003final, clear
append using 2005final

//Drop variables that are unnecessary

drop if value > 350000
drop if value <10000
drop if unitsf > 4500
drop if unitsf < 500
drop if lot > 968000
drop if lot < 1000
drop if amte > 260
keep if amtg<340 | amtg==.
drop if amto > 400
drop if baths >5
drop if floors >7
drop if zinc > 950000

//keep only the housing units that were surveyed in 2001 and 2003
sort control year
duplicates tag control, gen(duplicate)
drop if duplicate ==0
  save fdmerge03-05, replace

  ***********************************************************

//Fixed Effect Models
```

```
//Stata Verson 10
clear
cd "C:\Users\Caleb Lande\Desktop\thesis\thesis\stata dta files
ahs\final datasets
use fulldataset
xtset control year

by control: gen cfloors = floors - floors[_n-1]
by control: gen cbaths = baths - baths[_n-1]
by control: gen cbedrms = bedrms - bedrms[_n-1]
by control: gen ccellar = cellar - cellar[_n-1]
replace cfloors =0 if cfloors ==.
replace cbaths =0 if cbaths ==.
replace cbedrms =0 if cbedrms==.
replace ccellar=0 if ccellar==.


sort control year
duplicates tag control, gen(duplicate3)
keep if duplicate3 ==3


// Small Model with time and fixed effects
xtreg value amte amtg amto lras bedrms baths year_01 year_03 year_05
zinc, fe robust
eststo Small

// Large model with time and fixed effects
xtreg value amte amtg amto airsys lras bedrms baths dish displ fplwk
trash ///
year_01 year_03 year_05 zinc, fe
eststo Full

esttab Small Full using fd.rtf,  rtf replace b(a1) wide ///
starlevels(* .1 ** 0.05 ) ///
stats(N r2 r2_a F p ,fmt(a2 a3 a3 a2 2)star(F) labels("n" "R-square"
"Adjusted R-square" "F" "p-value")) ///
title("Estimation Results for Difference in Difference Model")   mla-
bels(, titles lhs("Model:")) ///
nonumbers mgroups("Value", lhs("Dependent Variable:") pattern(1 1 1))
///
label varlabels( _cons "Constant") nogaps
*******************************************************************
*******************


//Descriptive Statistics

quietly reg value value amte amtg amto airsys lras dish displ fplwk
trash ///
year_99 year_01 year_03 year_05 zinc, robust
eststo Full
estadd summ, mean sd min max
eststo descript

esttab descript using fdsumm2, rtf replace ///
cells("mean(fmt(2)) sd(fmt(2)) min(fmt(1)) max(fmt(1))")  ///
stats(n, fmt(0) labels("n")) ///
```

```
title("Descriptive Statistics") mlabels(,none) collabels("Mean"
"Std.dev." "Min." "Max.") nonumbers ///
drop(_cons) nogap label


quietly reg value value amte amtg amto airsys lras dish displ fplwk
trash ///
year_99 year_01 year_03 year_05 zinc if year_05==1, robust
estadd summ, mean
eststo descript1

quietly reg value value amte amtg amto airsys lras dish displ fplwk
trash ///
year_99 year_01 year_03 year_05 zinc if year_03==1,robust
estadd summ, mean
eststo descript2

quietly reg value value amte amtg amto airsys lras dish displ fplwk
trash ///
year_99 year_01 year_03 year_05 zinc if year_01==1,robust
estadd summ, mean
eststo descript3

quietly reg value value amte amtg amto airsys lras dish displ fplwk
trash ///
year_99 year_01 year_03 year_05 zinc if year_99==1, robust
estadd summ, mean
eststo descript4

esttab descript1 descript2 descript3 descript4 using fdsumm1, rtf re-
place ///
cells("mean(fmt(2))") ///
stats(N, fmt(a0) labels("n")) ///
title("Descriptive Statistics by Year") mlabels(,none) colla-
bels("Mean") nonumbers ///
drop(_cons) nogap label

*******************************************************************
*********************

// age segmentation
xtreg value amte amtg amto lras bedrms baths year_01 year_03 year_05
zinc if hhage <30, fe robust
eststo  age1
estadd summ, mean sd min max
eststo descript1
xtreg value amte amtg amto baths bedrms lras year_01 year_03 year_05
zinc if hhage >30 & hhage <65, fe robust
eststo age2
estadd summ, mean sd min max
eststo descript2
xtreg value amte amtg amto baths bedrms lras year_01 year_03 year_05
zinc if hhage >65, fe robust
eststo age3
estadd summ, mean sd min max
eststo descript3

esttab Small age1 age2 age3 using fd.rtf,  rtf replace b(a1) wide ///
```

```
starlevels(* 0.05) ///
stats(N r2 r2_a F p ,fmt(a2 a3 a3 a2 2)star(F) labels("n" "R-square"
"Adjusted R-square" "F" "p-value")) ///
title("Estimation Results for Difference in Difference Model")   mla-
bels(, titles lhs("Model:")) ///
nonumbers mgroups("Value", lhs("Dependent Variable:") pattern(1 1 1))
///
label varlabels( _cons "Constant") nogaps

*********************************************************************
****************************
// Income Segmentation

gen class1 = cond(year_01 ==1 & zinc < 60000,1,0)
gen class2 = cond(year_99 ==1 & zinc < 60000,1,0)
gen class3 = cond(year_03 ==1 & zinc < 60000,1,0)
gen class4 = cond(year_05 ==1 & zinc < 60000,1,0)
replace class1 =1 if class2==1
replace class1 =1 if class3==1
replace class1 =1 if class4==1
drop class2 class3 class4


xtreg value amte amtg amto lras bedrms baths year_01 year_03 year_05
zinc if class1 ==1, fe robust
eststo inc1
xtreg value amte amtg amto lras bedrms baths year_01 year_03 year_05
zinc if class1 ==0, fe robust
eststo inc2

esttab Small inc1 inc2 using fd.rtf,  rtf replace b(a1) wide ///
starlevels(* .1 ** 0.05 ) ///
stats(N r2 r2_a F p ,fmt(a2 a3 a3 a2 2)star(F) labels("n" "R-square"
"Adjusted R-square" "F" "p-value")) ///
title("Estimation Results for Difference in Difference Model")   mla-
bels(, titles lhs("Model:")) ///
nonumbers mgroups("Value", lhs("Dependent Variable:") pattern(1 1 1))
///
label varlabels( _cons "Constant") nogaps
*********************************************************************
**************
//Education Segmentation

xtreg value amte amtg amto lras bedrms baths year_01 year_03 year_05
zinc if hhgrad0 == 1 | hhgrad1 ==1 | hhgrad2==1 , fe robust
eststo educ1

xtreg value amte amtg amto lras bedrms baths year_01 year_03 year_05
zinc if hhgrad3 == 1 | hhgrad4 ==1 | hhgrad5==1 , fe robust
eststo educ2
esttab Small educ1 educ2 using fd.rtf,  rtf replace b(a1) wide ///
starlevels(* .1 ** 0.05 ) ///
stats(N r2 r2_a F p ,fmt(a2 a3 a3 a2 2)star(F) labels("n" "R-square"
"Adjusted R-square" "F" "p-value")) ///
title("Estimation Results for Difference in Difference Model")   mla-
bels(, titles lhs("Model:")) ///
nonumbers mgroups("Value", lhs("Dependent Variable:") pattern(1 1 1))
///
```

```
label varlabels( _cons "Constant") nogaps

******************************************************************
********************
// Xtoverid test eliminating random effects
/*
xtreg value hhage hhage2 amte amtg amto baths bedrms    ///
dish displ fplwk ///
lras year_*   zinc, fe cluster(control)
eststo a
xtreg value hhage hhage2 amte amtg amto baths bedrms    ///
dish displ fplwk ///
lras year_*   zinc, re cluster(control)
eststo b
xtoverid
xtoverid, cluster(co)
```

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