ORNL/TM-10727

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Gas Furnace Purchases: A Study of Consumer Decision Making and Conservation Investments

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OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes—Printed Copy: A07; Microfiche A01

ORNL/TM-10727

GAS FURNACE PURCHASES:

A STUDY OF CONSUMER DECISION MAKING AND CONSERVATION INVESTMENTS

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Date Published: October 1988

Prepared by the
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400

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Background

A major policy objective of the Department of Energy (DOE) and other energy agencies is encouraging the optimal use of energy-saving appliances in the residential market. However, the pursuit of this objective has met with a number of difficulties related to our understanding of how and why a consumer chooses energy-using durables. This study assists the DOE Office of Business and Community Systems (OBCS) by unraveling some of the issues involved in the consumer-choice problem in the particular case of replacement gas furnaces.

Objective

It is likely that many market-failure reasons and major insights from several theoretical frameworks are relevant to the replacement gas furnace problem. However, little is known about the overall implications. Which factors are most important and to what extent policy actions can alter the investment decisions remain largely unanswered questions. Additionally, there is little basis for discriminating among the factors to suggest efficient policy actions. The objective of this report is to address these concerns by studying a national survey of consumers who recently purchased a gas furnace. The focus is on the decision-making process of consumers and the analysis concentrates on testing some hypotheses suggested by the literature and past policy actions.

Approach

The survey resulted in 639 usable responses for the general analysis. Three methods of analysis are applied to the survey data: statistical analysis of survey responses about the actual purchase; analysis of hypothetical-choice problems that were part of the survey; and simulation analysis to compare actual choices with those selected by a cost-minimizing model.

Results

Energy efficiency information was not well understood by a majority of the respondents. However, respondents generally indicated that they received sufficient information about a broad range of furnaces to make their selections, although 40% of the sample contacted less than three suppliers and shopped one week or less for the new furnace. Shopping efforts were found to affect the likelihood that a consumer selected a high-efficiency furnace negatively. Furthermore, this effect was exacerbated by contacting more suppliers in a shorter time period.

The most popular reasons indicated for a specific furnace choice were the energy-efficiency rating and saving energy. However, respondents selecting high-efficiency furnaces tended to exhibit a measurable "conservation ethic" by other decisions such as insulation in the home and the hypothetical choice problems. Selected a high-efficiency furnace was positively related to heating degree days, level of education (of the respondent's spouse), level of income, the presence of an elderly family member, and living in the midwest or west. Two factors found not to have a significant influence on the purchase decision were credit availability or terms and discount rates. An important result from the hypothetical choice problems was that implied respondent discount rates were 6 to 15%, much lower than the 25 to 45% range suggested by other studies.

We found that for about two thirds of the sample, the old furnace was still working at the time the new furnace was purchased. Furthermore, there were only slight differences in the reasons for purchase between the operating and non-operating groups. The non-operating group of respondents was more likely to purchase because the unit was in stock and less likely to purchase because of the energy efficiency and brand name.

Finally, using a heating-use simulation model and respondent-specific data on house characteristics, we found that just less than half of a selected subset of the sample chose an energy-efficiency level that minimized the discounted total cost of heating. The remaining respondents' choices were easily reconciled with the cost-minimizing model after considering additional factors like oversizing the furnace, gas-price expectations, and beliefs about resale values.

Conclusions

Policy initiatives aimed at increasing the diffusion rates of high-efficiency furnaces should concentrate on younger homeowners and consumers living in the southern region since these groups tend to buy low-efficiency furnaces. However, the objective of these initiatives should not be simply to increase shopping efforts, as this activity seems to have the opposite of the desired effect. Increased information on properly sizing a furnace may help, since our results indicate that furnaces are systematically oversized.

In addition, policy initiatives aimed at lowering credit rates or dispelling a perceived capital-cost barrier will not be effective means to encourage high-efficiency furnace purchases. These factors have little to do with any perceived limitations to selecting a high-efficiency furnace. A potential barrier to the selection of a high-efficiency furnace by an emergency buyer is whether or not such units are routinely kept in stock. Since high-efficiency furnaces represent a more costly inventory for a dealer, dealers may prefer to sell them on a order basis only.

In actual purchases, consumers tend to follow the rules of a cost minimizer more closely than they do when making hypothetical choices. This suggests that conventional diffusion models may do fairly well at predicting market penetration rates. However, the consumers in our sample for which this conclusion applies were demonstrated to be more aware of furnace information than the general sample.

1. INTRODUCTION

The events of the last two decades have focused attention on the efficient use of energy resources. Consequently, a major policy objective of the Department of Energy (DOE) and other energy agencies is encouraging the optimal use of energy-saving appliances in the residential market. However, the pursuit of this objective has met with a number of difficulties related to our understanding of how and why a consumer chooses energy-using durables. The purpose of this study is to assist the DOE Office of Business and Community Systems (OBCS) by unraveling some of the issues involved in the consumer-choice problem in the particular case of replacement gas furnaces. A national survey of furnace purchases consisting of 639 responses is analyzed to answer some of the questions relevant to appropriate policy actions.

The first relevant question we may ask is, why is investment in energy-saving durables such as furnaces a public policy concern? The answer has often been derived from an argument based on the failure of the private market to result in optimal investment levels for these durables. The market-failure justification is based, in part, on the proposition that private valuations of the investments diverge from the social valuations. The reasons for the divergence include: differences among consumers in knowledge about alternative investments; divergences between the marginal cost of energy resources and the prices consumers actually face; differences in the social and private discount rates;[1]

[1]The discount rate is defined as the rate by which a future value is made equivalent to a present value. For example, if someone's annual discount rate is .10, a dollar next year is worth $.91 today.

differences in the social and private time horizons;[2] and related housing-market failures that prevent adequate capitalization of the energy savings that result from conservation investments. Furthermore, the furnace investment involves comparisons among alternatives that differ in important characteristics. Comparisons require that consumers pay attention to a range of attributes of the furnaces, e.g., purchase price, heating capacity, physical size, and energy efficiency.[3] Such a comparison may be very difficult for consumers to make. There is a growing literature in consumer-decision making that addresses the cognitive problems involved in such investments.[4]

The second relevant question that may be asked is, what is the appropriate theoretical framework by which conservation-investment decisions should be studied for policy purposes? Dinan (1985, 1987) provides a review of three common frameworks that have been applied to the investment problem. The first, which we will call the simple economic-man framework, hypothesizes that consumers select among alternative furnaces to minimize the total cost of providing the heating service. Thus, they review alternative models on the basis of the major characteristics (capital cost, efficiency, heating output), and make a

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[2]Time horizon is defined as the number of time periods over which the investment is evaluated.

[3]Energy efficiency is defined as the percentage of input energy converted to usable heat over a full year's operation. In the discussion, we use the term interchangeably with the annual fuel utilization efficiency (AFUE) which is the standard measure for the fuel usage of furnace equipment.

[4]See Dinan (1985, 1987) in particular for a review of the literature pertaining to conservation investments.

selection based upon their own discount rate, time horizon and heating needs.

The second framework focuses on the influence of attitudes on consumer investments. For example, the attitude that saving energy is desirable for its own sake (a conservation ethic) may influence a consumer to purchase a high-efficiency furnace. Finally, the third framework attempts to illuminate the boundedness, or limited capacity, of the consumer's decision-making process in its ability to make comparisons across investment alternatives. Thus, this framework has evolved from a basic criticism of the calculating rationality underlying the simple economic-man framework. For example, a commonly asked question is, can consumers perform the mathematical calculations necessary to compare alternative life-cycle costs for different furnace options?

It is likely that all of the market-failure reasons and major insights from the theoretical frameworks are relevant to the replacement gas furnace problem. However, little is known about the overall implications. Which factors are most important and to what extent policy actions can alter the investment decisions remain largely unanswered questions. Additionally, there is little basis for discriminating among the factors to suggest efficient policy actions. In response to these concerns, this report presents a study of a national survey of consumers who recently purchased a gas furnace. The focus is on the decision-making process of consumers and the analysis concentrates on testing some hypotheses suggested by the literature and past policy actions.

In the next chapter, we discuss five views of the problem to describe how the problem has been approached in the past and the various solutions that are consistent with these views. From this review, we derive a set of testable hypotheses and discuss the relationship with the survey design. Chapter 3 presents the analysis of the purchase decision for the total sample. An analysis of identified energy efficiency choices for a subset of the sample is presented in Chapter 4. This is followed in Chapter 5 by a comparison of the simple economic-man framework with efficiency choices of the identified group. The purpose of the comparison is to suggest how the simple economic framework may be augmented to provide a more robust description of consumer decision making. Chapter 6 contains conclusions and policy recommendations.

2. THE GAS FURNACE PROBLEM

The gas furnace problem is part of a larger class of consumer-investment problems that involve durable goods. Durable goods are not consumed completely in one application. They have a time-dimension to their provision of consumption services. In general, these goods are low frequency purchases and represent a non-trivial share of the consumer's budget. Houses, refrigerators, cars, and furnaces are all examples of durable goods. Such purchases involve a difficult decision process because different types of costs (capital, operating, maintenance, etc.) must be considered over time for each potential choice. A formal life-cycle cost analysis will require the consumer to understand how discount rates, time horizons, heating needs, and resale values affect the cost tradeoffs for the considered furnaces.

Because furnace purchases are low frequency, consumers do not have the same sampling opportunities as with other goods like food or clothing. Where sampling opportunities are limited, the consumer will have limited experience with the attributes of the durable good. This is a particularly severe problem with something like a furnace, which can be out of sight, out of mind after it is installed.[1] Information about performance and costs is generally limited to advice from the dealer, publications, and advice from friends and neighbors. Because it is

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[1]There is generally much less opportunity to sample among furnaces than other durables, such as cars. Cars, even if owned by someone else are visibly on display and may be test driven before purchase. Furnaces are not displayed (although one may discuss heating bills with the neighbors) and no opportunity to try them out prior to purchase exists to our knowledge.

unlikely that the consumer will have any information from direct experience with the furnaces under consideration, what is already a difficult decision process becomes even more uncertain and complicated.

The large number of manufacturers and model numbers is another characteristic of the gas furnace market that may contribute to the complexity of the consumer's decision-making process. Appendix A reproduces a list of manufacturers as found in U.S. DOE (1982). The Consumers' Directory of Certified Furnace and Boiler Efficiency Ratings published by the Gas Appliance Manufacturers Association (GAMA) in 1987 lists about 6800 available model numbers and this includes only forced-air furnaces that are GAMA certified. For oil furnaces, there are about 1200 model numbers. The gas furnaces offered by any one manufacturer cover a wide band of efficiencies, for example, Lennox offers efficiencies from 64% to 95%. Obviously, consumers will have a difficult time searching through this extensive choice set. Hence, they are likely to let the furnace dealers do the first level of screening for suitable options. But if a consumer visits several dealers, the list of options to be considered could be quite large.

2.1. FIVE VIEWS OF THE EFFICIENCY-CHOICE PROBLEM

Analysts and policy makers have addressed the issue of encouraging investments in high efficiency appliances from a number of perspectives. Although not mutually exclusive, we can identify five alternative views on the problem and typically recommended solutions that encompass much of the previous work:

1) The Information View: Because consumers do not know what is available in the market, they have no way of adequately comparing

alternatives. Solutions include flooding the market with information, teaching consumers to make comparisons (e.g., Consumer Reports 1987), and regulating efficiency marking and standardization of appliances.

2) The Marketing View: Solutions will be found through an understanding of the nature of consumer choices. This involves an understanding by promoters of high-efficiency furnaces of the characteristics of the different types of consumers in the market. Evidence exists that high efficiency furnaces appeal to some groups but not all, therefore the more reluctant groups must be targeted in the appropriate way. Those espousing the marketing view argue that research is necessary on the correct incentive packages to make the high efficiency appliance more attractive to particular groups, and provide the means for overcoming attitude problems. The results of such research would aid in improving the accuracy of analytical models to predict consumer decision making. Solutions include market analysis and targeted incentive programs, e.g., programs for low income groups, targeted advertising, targeted energy audits, providing market data to sellers so that they can market more efficiently.

3) The Capital-Cost-Barrier View: Because high-efficiency furnaces cost more than low-efficiency ones, discount rates, time horizons, perceived resale values and budget considerations will be critical in the selection process. Consumers are believed to have high discount rates for furnaces (Ruderman et al. 1986). Favorable credit incentives or capital cost subsidies can eliminate the

capital-cost barrier. Recommended solutions generally focus on low-cost loans provided by utility programs and state or federal tax incentives.

4) The Irrationality View: This view holds that the complexity of the furnace decision makes it unlikely that consumers make rational economic decisions. In such circumstances, they have very bounded rationality and rely on inappropriate rules of thumb or advice from sellers. Consumers lack the incentive to be more diligent in their decision making process because these purchases are very infrequent and information about the various attributes of the appliance is costly to obtain. It is also argued that they tend to buy such items as a furnace in a crisis situation, i.e., when the current furnace stops working. Finally, consumers may not be making the decision at all, rather it is being made for them by some intermediary like a builder, superintendent, or landlord. Even in the case of the replacement furnace this may be true with renovation work and condominiums. Solutions associated with this view accept that consumers are irrational. Proposed solutions work on the supply-side of the market, e.g., provide incentives to sellers to raise the average efficiency levels or regulate efficiency levels in the industry.

5) The Consumers-are-Rational View: In contrast to the irrationality view, proponents of this view argue that consumers choose efficiency levels that reflect their heating needs, discount rates, time horizons, and costs (Friedman 1987). We may think of this view as espousing the model of Economic Man. Here, the solution is

relatively simple. If choices are optimal and reflect valid economic considerations, then policy should be to do nothing.

2.2. THE SURVEY INSTRUMENT

The national survey that was conducted for this analysis was administered through Market Facts, Inc. Market Facts maintains a mail panel data group consisting of 220,000 households throughout the U.S. A balanced national sample was selected from this groups so as to match proportionally the U.S. statistics on five demographic variables: geographic region, population density, household income, age of panel member, and household size. This selection resulted in an original sample population size of 75,000 households. After a screening process, the survey was administered to 972 households from the original population that said they purchased a replacement gas furnace between March 1, 1985 and February 28, 1987. Of these, we received 639 responses for analysis. Table 1 presents the demographics of the respondent sample. A more detailed discussion of the survey process and the questionnaire are contained in Appendix B.

The design and instructions of the survey were carefully tailored to the selection process relevant to the choice of one gas furnace over other alternative gas furnaces. Thus, we simplified the selection process of interest by removing the complication of whatever fuel-choice decision process had occurred. We believe this constraint on the scope of the survey was reasonable not only to limit the number of questions, but also because the fuel-choice decision is likely to precede any particular furnace decision or selection of efficiency levels.

Table 1. Demographics of sample

Variable	% of Sample
Region	
New England	2
Middle Atlantic	13
East North Central	31
West North Central	10
South Atlantic	13
East South Central	6
West South Central	12
Mountain	5
Pacific	8
Population Density	
Non-MSA (rural)	19
Small MSA (50,000-499,999)	21
Medium MSA (500,000-1,999,999)	30
Large MSA (2,000,000 and over)	31
Income	
Under $10,000	11
$10,000 - $17,499	16
$17,500 - $24,999	18
$25,000 - $39,999	28
$40,000 and over	28
Mean: 31,750 Std: 29,040	
Age	
Under 30	9
30 - 39	21
40 - 49	17
50 - 59	21
60 and older	32
Mean: 49.49 Std: 13.9	
Household Size	
1 person	16
2 persons	38
3 persons	17
4 persons	16
5 or more persons	12
Presence of Someone 6 or Younger	
None	91.0
1 person	7.7
2 people	1.1
Presence of Someone 65 or Older	
None	68.1
1 person	19.1
2 people	12.4

The survey instrument was designed to cover a number of areas we believed affected the purchase decision. These areas include:

1. Comparison of the new and old furnaces.
2. Factors influencing the decision to purchase the selected gas furnace.
3. Heating-needs factors.
4. Cost and financing factors.
5. Shopping efforts.
6. Energy efficiency: understanding and exposure to the information.
7. The relationship between purchase price and efficiency.
8. The relationship between energy efficiency and resale value.
9. Discount rates elicited from hypothetical choice problems.

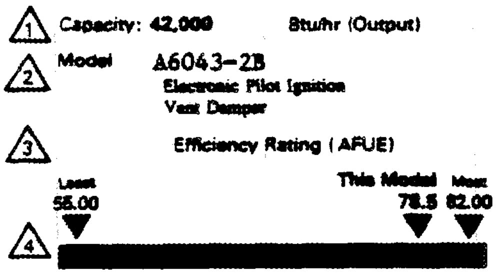
The comparison questions were asked to detect some basic reasons for replacing the old furnace: operation, heating capacity, energy efficiency, brand name, and safety. The factors influencing the purchase choice, what we call the selection criteria, were probed by a list of 25 factors (including "other") and respondents were asked to first check the influential factors, then select the five most influential, and finally to rank the five most influential from 1 to 5.

Heating-needs factors (time horizon, heated square footage of home, temperature settings, and perceived insulation levels) were asked to understand the relationship between user types and efficiency levels. The cost and financing questions attempted to uncover capital-cost barriers. The shopping effort and energy efficiency questions were asked to investigate information and search differences among consumers. To understand perceptions of the efficiency-cost tradeoff and resale potential of high efficiency furnaces, we asked respondents to make some simple comparisons involving hypothetical furnaces. This approach was used also to elicit indirectly respondent discount rates over five alternative furnaces.

Issues probed by the survey reflect directly on the reasonableness of each of the five views discussed above. We use each of the views to generate a set of questions that either support or contradict the basic assumptions of the view. These questions are then tested in the analysis of the next three chapters. The set of questions for each view is as follows:

1. The Information View: Another way of stating this view is to ask whether or not consumers have adequate information about furnace efficiencies. Our definition of adequate reflects both exposure and credibility concerns. We know that the Federal Trade Commission (FTC) requires a fact sheet to be available for every residential furnace at the point of sale. See Fig. 1 for an example. However, the label on the furnace need only direct the consumer to the information, it need not actually report the information. The problem, we have been told, is that dealers often cannot find the correct fact sheet pertaining to a particular furnace when it is requested. In addition, the cost comparison is a very crude representation of what consumers will actually pay, since it is not tailored to particular weather areas. Thus, although the fact sheet appears to offer a solution to the information problem, it may be far from satisfactory. Questions suggested by this view are:

    a) Do consumers know the energy efficiency of the unit they purchased?
    b) Was it marked on the furnace?
    c) Was it consistent with the recommendation of the dealer?
    d) Was the consumer offered a broad range of efficiencies?
    e) Do consumers believe that the energy efficiency ratings are accurate indications of energy use?
    f) Do consumers appear to understand the tradeoff between capital cost and energy efficiency?



*Comparative National Average Yearly Cost ($) Information 6

Cost Per Therm of Nat. Gas	Btu/hr Heat Loss of Home (1,000's) 5		
	15	(20)	25
10c	$ 42	$ 55	$ 69
20c	$ 71	[illegible]	$118
(30c)	$101	($134)	$168
40c	$130	[illegible]	$217
50c	$160	$213	$268
60c	$190	$253	$318

1 Capacity of the furnace in Btu/hr (output).

2 Furnace model number. (this model has electronic pilot ignition and vent damper identified.)

3 The efficiency rating given in Annual Fuel Utilization Efficiency (AFUE).

4 The bar scale show the efficiency comparison of all listed furnaces (both this model and competing brands) for a given Btu/hr range. This model with 42,000 Btu/hr is compared to all gas furnaces in the 26,000 to 42,000 Btu/hr output range. The least efficient model rating in this range is on the left (55.00) and the most efficient on the right (82.00). The placement of this model (78.5) is proportionate to the least and most.

5 The yearly operating cost is based on two variables; the cost of gas (per therm) and the heat loss of the home.

6 The yearly cost information is based on the national average of 2080 heating load hours.

Fig. 1 The FTC fact sheet

2) The Marketing View: Testable hypotheses that emerge from this view are related to whether or not certain socio-economic characteristics are associated with either attitudes or behavior consistent with making energy-efficient investments. We consider 12 socio-economic factors to be tested for a correlation with different criteria for purchase and selected efficiency levels: income; education; age of respondent; presence of person 65 years or older in the household; presence of person 6 years or younger in the household; family size; length of expected occupancy in the home at the time of purchase; region; heating degree days (HDD); square footage of the heated portion of the home; perceived insulation level of the home; and type of dwelling.

3) The Capital-Cost-Barrier View: The basis for this view is that the capital cost/operating cost tradeoff for consumers is highly biased by private discount rates, time horizons, and related market failures in the housing market. Researchable questions that reflect upon this view include:

   a) Are discount rates high for gas furnace purchases?
   b) Are time horizons very short?
   c) Is the perceived resale value for an efficient furnace very low?
   d) Is ability to finance a constraint on the choice process?

4) The Rationality/Irrationality Views: Because these views are at extreme with one another, testable hypotheses are related. The answers to these questions will necessarily support one view over the other. Important to these views is the ability of the consumer to make an informed, rational choice. We define this choice as the one that minimizes the life-cycle cost of providing heating services

based upon the particular economic factors faced by the decision maker. Thus, our definition of rational behavior assumes that consumers are cost minimizers. This narrow definition of rationality is typically associated with models known in the economics literature as "economic-man models." With this in mind, we examine the data for answers to the following questions:

a) Do consumers make use of published information on furnaces?
b) Is switching among the hypothetical options rational?
c) Was this an emergency purchase? Does it matter?
d) How does the simple economic-man framework compare with actual choices? Can we reconcile the two?

The next three chapters contain the analysis of the survey responses. In Chapter 3, the total sample is used to test hypotheses regarding the important socio-economic factors, important criteria for purchase, and the relationship between purchase criteria and socio-economic factors of the respondents, as well report the responses of the total group for the other issues covered by the survey. In Chapter 4, we present the analysis of the subsample for which energy efficiency ratings could be identified and explore relationships among efficiency levels, reasons for purchase, and socio-economic factors. This is followed by the economic-man comparison for this group.

3. ANALYSIS OF THE PURCHASE DECISION

3.1. DESCRIPTIVE ANALYSIS OF THE SAMPLE

A number of socio-economic factors have been suggested in the literature as bearing some influence on conservation behavior (Dinan 1985, 1987 and Baxter et al. 1986). We concentrate on 12 factors that are consistently mentioned in the behavioral studies: income; education; age of respondent; presence of person 65 years or older in the household; presence of person 6 years or younger in the household; family size; length of expected occupancy in the home at the time of purchase; region; heating degree days (HDD); square footage of the heated portion of the home; perceived insulation level of the home; and type of dwelling.

The 639 respondents in this study have a mean income of $31,750 and mean age of 49.5 years (see Table 1). Two-member households make up over a third of the sample, which is consistent with the age information. The majority of the respondents are married and over half of them have some college education (see Table 2). Over a third of the respondents expected to remain in their homes for 10 to 20 years at the time they purchased their new furnace. A fifth of the sample could not estimate the heated square footage of their home. Most people said their homes were well insulated which was defined as: Has storm windows and storm doors; has good caulking and/or weatherstripping; has good ceiling and floor insulation. The majority of respondents own and live in single-family detached homes.

Table 2. Basic socio-economic factors

Variable	% of Sample
Marital Status:	
Married	67.8
Widowed	10.8
Divorced	10.2
Separated	.9
Never Married	10.2
Not Specified	.2
Education of Panel Member:	
Any Grade School	2.7
Any High School	43.7
Any College	39.6
Any Post-College	13.0
Expected Length of Occupancy:	
Less Than Five Years	13.6
5 - 10	17.8
11 - 15	10.5
16 - 20	24.4
20 - 25	6.6
26 - 80	14.3
No Answer	12.8
Square Footage of Heated Part of Home:	
Less than 1000	16.6
1001 - 1200	10.4
1201 - 1500	15.0
1501 - 2000	18.0
2001 - 3000	13.8
3001 - 8000	4.1
No Answer	21.9
Heating Degree Days:	
0 - 1999	8.6
2000 - 3999	21.4
4000 - 5999	29.1
6000 - 7999	37.1
8000 - 9999	3.8
Insulation Level of Home:	
Well Insulated	62.4
Adequately Insulated	27.1
Poorly Insulated	7.5
No Answer	3.0

Table 2. Basic socio-economic factors (cont'd)

Variable	% of Sample
Type of Dwelling:	
Mobile Home or Trailer	5.8
Single Family Detached	85.9
Single Family Attached	3.1
Duplex	3.3
Triplex or Larger	1.6
No Answer	.3
Ownership of Home:	
Owned by Household	96.4
Rented by Household	3.4
No Answer	.2

A correlation matrix of socio-economic factors is shown in Table 3. The variables in this table are defined as:

SQFT - Heated square footage
HH - Number of household members
ELD - Number of household members 65 and over_
YNG - Number of household member under 6
INC_L = 1 if 1985 income is less than $12,500
INC_H = 1 if 1985 income is $40,000 or higher
ED1_L = 1 if panel member has 3 years of high school or less
ED1_H = 1 if panel member has 4 years of college or more
ED2_L = 1 if spouse has 3 years of high school or less
ED2_H = 1 if spouse has 4 years of college or more
INS_W = 1 if dwelling is described as well insulated
INS_P = 1 if dwelling is described as poorly insulated
DWL_T = 1 if dwelling is a trailer
DWL_M = 1 if dwelling is multi-family unit
AG1_O = 1 if panel member is 65 or older

Values less than .15 are suppressed in Table 3 to clearly highlight the larger correlations. The signs and magnitudes of these correlations are generally quite reasonable. High income, for example, is positively correlated with household size, square footage, and high education and negatively correlated with the number of household members over 65 and the indicator variable for living in a trailer.

Eighty-five percent of the sample purchased their furnace between March 1, 1986 and February 28, 1987. The remaining 15% purchased between March 1, 1985 and February 28, 1986. Thus, by design, the sample consists of fairly recent purchases. This was done to accommodate respondents so they could reasonably recall details about the purchase decision and for consistency in relative prices and model selection faced by the consumer. We find that most respondents can tell us a brand name for their furnace (only 12% missing),[1] but nearly 40% cannot tell us the

[1]See Appendix C for a listing of the various brand names reported by respondents.

Table 3. Correlation of socio-economic factors

		1	2	3	4	5	6	7	8
1	HH	1							
2	SQFT	.15	1						
3	ELD	-.31		1					
4	YNG	.30		-.15	1				
5	INS_W			.17		1			
6	DWL_T		-.17				1		
7	INC_H	.17	.30	-.23			-.15	1	
8	INC_L	-.22	-.19	.19			.15	**	1
9	ED1_L			.15				-.17	.28
10	ED1_H		.20					.16	-.16
11	ED2_L							-.16	
12	ED2_H		.23					.25	-.16
13	AG1_O	-.16		.59				.19	

		9	10	11	12	13
9	ED1_L	1				
10	ED1_H	**	1			
11	ED2_L	.23		1		
12	ED2_H		.28	**	1	
13	AG1_O				.18	1

** Suppressed correlation value of functionally related category variables model number. While this number is located on the furnace, the furnace is likely to be difficult to access so we are not surprised at the response rate. From the data on brand name and model number, we are able to identify 213 furnaces and their energy efficiencies from GAMA (1986 and 1987). The 213 cases are used in the analysis of identified efficiency levels in Chapter 4.

3.2. FACTORS IMPORTANT TO THE PURCHASE DECISION

3.2.1. Comparison with the Old Furnace

To understand the motivational basis for the selection of a particular gas furnace, and hence, a certain level of efficiency, respondents were asked a series of questions about the reasons for their choice. The first set of questions concentrated on a comparison with the old furnace. The variables and response percentages[2] for these variables are shown in Table 4.

The majority of the sample replaced a gas furnace. The second most likely type of furnace to be replaced was an oil furnace. This result makes some sense given the substitutability of the systems in most homes. Surprisingly, 74% of the people replaced their furnace while the old furnace was still working. This contradicts the perception that the purchase is an emergency. The data also show that 64.5% of the respondents said that they purchased their new furnace because they suspected that the old furnace was about to break down. However, a logit

[2]Response percentages add to less than one because of missing responses. A "don't know" is not considered a missing response.

Table 4. Comparison with the old furnace

Variable (No. of Responses)	%
Type of Furnace Replaced (609)	
Gas	76.0
Electric	3.3
Heat Pump	2.0
Oil	11.4
Don't know	2.5
Old Furnace Still Operating (613)	
Yes	74.1
No	20.1
Don't know	1.6
Same Capacity (585)	
Yes	26.1
No	55.2
Don't know	10.2
Same Energy Efficiency (580)	
Yes	6.1
No	76.8
Don't know	7.8
Same Brand Name (581)	
Yes	8.5
No	77.0
Don't know	5.5
Same Model Number (577)	
Yes	1.6
No	80.3
Don't know	8.5
New is More Energy Efficient (568)	
Yes	72.3
No	13.9
Don't know	2.7
Suspected the Old Furnace Was About to Break Down (579)	
Yes	64.5
No	23.8
Don't know	2.3
New is Safer than Old (545)	
Yes	55.2
No	18.2
Don't know	11.9

analysis[3] of the two variables reveals that the association is not significantly different from zero. In other words, there was not a significant proportion of the still-operating group who believed their furnaces were about to fail. A cross tabulation shows that only 312 respondents said yes to both questions. Thus, for about a quarter of the sample, the purchase was not motivated by an emergency or the belief that the old furnace was about to fail.

In general, respondents did not buy the same capacity or energy efficiency as the old furnace. Most respondents (72.3%) said that they bought their new furnace because it is more energy efficient than the old one. A logit analysis showed that respondents who did not buy the same capacity also tended to say that they purchased their new furnace because it was more energy efficient than the old one. Because there is a size-efficiency tradeoff with respect to cost, it would have been useful to know if the new capacity exceeded that of the old furnace. We return to this issue in Chapter 5.

Respondents seem to be aware of differences in the brand and model number of their new furnace and the old one. The question on model number is really a check on awareness, since it is highly unlikely that the model numbers could be the same. In fact, these numbers often change

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[3]In examining a variety of issues, a logit model is frequently employed in this study. Many similar studies have used discriminant analysis (most likely due to computational ease, in that OLS procedures can be used to estimate a linear discriminant function). We note that the discriminant-analysis estimator is the true maximum-likelihood estimator (MLE) and therefore is asymptotically more efficient than the logit MLE, if the independent variables are normally distributed. However, if the independent variables are not normal, the discriminant-analysis estimator is not even consistent, whereas the logit MLE is consistent and therefore more robust.

annually (see GAMA 1986 and 1987). More uncertainty exists over whether safety was a reason for purchase. Nearly 12% responded that they did not know if greater safety was a reason for purchase. Of those that did know, a little over half said safety was a reason.

3.2.2. Influential Factors

To investigate further the selection criteria, we asked respondents to tell us whether a particular factor was relevant to their selection process. After answering either yes or no, respondents were then asked to check the five most influential factors in their selection process. Lastly, respondents were asked to rank the five most influential factors from 1 to 5 (1 being most important). Twenty-four listed factors and "other" are explored in this way. The listed factors and their variable names are:

a. The advice of dealer/salesperson/utility company (DEALER).
b. The recommendation of a friend/neighbor/relative (FRIEND).
c. How long I expected to remain in my home (OCCUPANCY).
d. Saving energy (ENERGY).
e. The payback period (PAYBACK).
f. An inexpensive purchase price (LOW PRICE).
g. Inexpensive fuel costs (LOW FUEL).
h. Inexpensive maintenance costs (LOW MAIN).
i. Inexpensive installation costs (LOW INSTALL).
j. The unit was in stock (IN STOCK).
k. The physical size of the unit (SIZE).
l. The energy-efficiency rating of the unit (EER).
m. Increasing the value of my home (RESALE).
n. Reliability of the installer (RELIABILITY).
o. Buying the same furnace as the old one (SAME AS OLD).
p. The brand name (BRAND).
q. The heating capacity (HEAT).
r. A sale price (SALE).
s. The warranty (WARRANTY).
t. An extended service contract (SERVICE).
u. Delivery (DELIVERY).
v. Credit availability (CREDIT).
w. Furnace part of an appliance package (PACKAGE).
x. Publication, magazine, article (e.g., Consumer Reports) (INFORMATION).

Table 5 shows the responses as percentages of the total sample. Information is shown on whether or not the factor was important in the purchase decision. The factors are ranked by the percent of the sample that found the factor to be in the top five influential factors (column 4). The percentages for the rankings (among the five most influential factors) are listed in the last column only for those factors that are considered most influential by at least 18% of the sample.

From the percentages, there is strong evidence that saving energy, energy efficiency, and inexpensive fuel costs are important factors in the selection process. Since these factors are most closely related to the energy-resource use of the equipment, for brevity, we call them the efficiency factors. Influential factors other than the efficiency are: advice of the dealer, expected length of occupancy, inexpensive maintenance costs, increasing the value of the home, reliability of the installer, and the heating capacity. However, only the advice-of-the-dealer factor rivals the efficiency factors in the preferences demonstrated by the rankings in the last column.

Information from Table 5 is useful for identifying another set of factors we consider to be relevant, but less important. These are factors that received affirmation from at least 40% of the sample as relevant, but were selected by less than 18% as most influential. These are: the payback period, inexpensive installation costs, the physical size of the unit, the brand name, the warranty, and delivery of the unit. Since many people are quoted one price for the equipment, the delivery and the installation costs, it is reasonable that the latter two factors were of less importance. What is very surprising is that an inexpensive

Table 5. Relevant factors in furnace selection

Factor	Yes*	No	Selected as Most Influential	Ranking (1, 2, 3, 4, 5)
ENERGY	83.6	12.1	61.0	21.1, 12.1, 9.4, 9.7, 5.5
EER	78.7	14.4	52.7	11.3, 14.6, 11.4, 7.4, 5.3
RELIABILITY	68.4	23.9	30.7	5.3, 3.8, 7.5, 7.4, 5.3
LOW FUEL	56.8	34.3	29.7	5.6, 5.9, 6.9, 6.4, 3.1
HEAT	67.0	22.7	26.1	3.9, 4.9, 6.1, 4.9, 5.0
DEALER	56.7	37.0	25.8	8.8, 4.7, 2.7, 4.9, 3.3
LOW MAIN	60.7	28.3	20.3	.8, 3.8., 4.1, 5.5, 4.7
OCCUPANCY	47.9	39.0	18.9	3.5, 3.4, 2.0, 3.1, 5.2
RESALE	46.2	45.9	18.3	2.2, 2.7, 3.1, 4.1, 4.4
SIZE	43.7	43.8	17.1	
BRAND	39.7	48.7	16.9	
LOW PRICE	30.0	60.4	15.8	
FRIEND	27.7	62.3	15.3	
PAYBACK	43.8	44.0	14.6	
WARRANTY	48.2	41.9	13.3	
LOW INSTALL	40.5	48.5	12.7	
IN STOCK	35.8	52.3	11.0	
SALE	24.6	63.5	8.5	
DELIVERY	40.8	48.2	8.5	
CREDIT	14.7	72.0	5.3	
SERVICE	18.9	69.2	3.3	
SAME AS OLD	5.2	83.4	2.7	
INFORMATION	9.4	77.9	2.7	
PACKAGE	3.0	86.2	1.3	

Note: *All numbers are percentages of total sample.

purchase price is selected by only 30% of the respondents. However, those that do select an inexpensive purchase price tend to be slightly younger and have slightly lower incomes than the group that did not select it.

Lastly, there is the third group of factors that may be considered only peripheral to the selection process. For these factors, over fifty percent of the sample said they were not relevant to the selection process. Three of them, the advice of a friend/neighbor/relative, an inexpensive purchase price, and the unit was in stock, are still listed in the most influential group by more than 10% of the sample, which suggests that they may be associated with either particular types of purchases (e.g., emergency) or particular types of consumers.

The other six factors, buying the same furnace as the old one, a sale price, an extended service contract, credit availability, appliance package, and publications, do not appear to have much affect on the selection process. The last of these is somewhat noteworthy. Publications regarding alternative furnaces were selected by only 17 respondents (2.7%) as falling in the most influential group. Interestingly, Consumer Reports featured an article on high-efficiency furnaces in January of 1987. The subject of the article was to assist consumers in evaluating alternative high-efficiency furnaces and to help them determine if replacement of their current furnace was advisable. Of course, it may be that most of the people in our sample had already purchased their furnaces by this time. However, our results do raise doubts that consumers have been seeking and using published materials that attempt to facilitate furnace comparisons.

The lack of importance for credit availability is relevant for the capital-cost-barrier view of the problem. Only 34 of the respondents said that this was one of the most influential factors in their selection process. The basis for this result may either be that consumers do not use credit for furnace purchases (as pointed out in Dinan (1985)) or that credit availability does not vary from one furnace alternative to another. The credit factor is explored again when we consider the remainder of the survey questions in part 3.3.

A correlation analysis, presented in Table 6, shows that certain associations can be identified among the factors. The advice of the dealer is negatively correlated with inexpensive fuel and maintenance costs, but positively correlated with the reliability of the installer. Saving energy is positively correlated with both operating costs (fuel and maintenance) as well as the energy-efficiency criteria. It is also positively correlated with increasing the value of the home. The operating costs, fuel and maintenance, are positively correlated as are the heating capacity and the energy-efficiency rating. One perplexing result is the negative correlation between the reliability of the installer and both fuel and maintenance costs. One possible explanation is that reliability of the installer is perceived as varying with greater installation costs and thus, is not likely to be selected by respondents that focus on low operating costs.

There were 67 respondents that said "other" reasons influenced their selection process. We checked the 46 of these that ranked "other" as the most important reason in the selection process. One person said that library research influenced the selection process. Eleven people said

Table 6. Correlations of significant factors

Correlation Matrix

Factor	DEALER	OCCUPANCY	ENERGY	LOW FUEL	LOW MAIN
DEALER	1.000				
OCCUPANCY	-0.009	1.000			
ENERGY	0.039	0.056	1.000		
LOW FUEL	-0.100*	-0.039	0.138*	1.000	
LOW MAIN	-0.119*	0.047	0.114*	0.195*	1.000

	DEALER	OCCUPANCY	ENERGY	LOW FUEL	LOW MAIN
EER	-0.036	-0.091	0.349*	0.098	0.031
RESALE	-0.020	0.021	0.138*	0.030	0.054
RELIABILITY	0.150*	0.010	-0.004	-0.111*	-0.106*
HEAT	-0.009	-0.040	0.081	0.028	0.074

	EER	RESALE	RELIABILITY	HEAT
EER	1.000			
RESALE	0.043	1.000		
RELIABILITY	-0.009	-0.078	1.000	
HEAT	0.149*	-0.033	0.014	1.000

*Relationships that are significantly different from zero at the .01 level using a logit analysis.

they were particularly influenced by a recommendation from a source they respected. One of these people said a Department of Energy recommendation was influential in the purchase of a high-efficiency furnace. In fact, the furnace selected had an energy-efficiency rating of 97%. Another highly respected source for recommendations is the plumber. We can only surmise that many plumbers also contract for heating and cooling needs or that these were cases where a gas boiler was being replaced.

Eight respondents said that the furnace they selected was part of a heating and air-conditioning package. In fact, several indicated that they had selected their air-conditioning unit and that the furnace was included at no additional cost. Six people said that peculiar structural requirements of their home limited their furnace options. Three others said the selected furnace was most suited to replace the original unit, e.g., compatibility with existing ducts. Three respondents said they were influenced by either a tax or rebate program. Two of the three purchased furnaces that are more than 90% efficient. Five people said that they bought their furnace through a relative at a reduced cost. The efficiencies that could be identified for these respondents averaged 80%.

Finally, six respondents told us that they were influenced by concerns of warmer heat or lower fuel bills. Several of these people complained about their previous heating source, an electric heat pump. What is notable about these cases is that their selection process appears to be based not on a comparison among alternative gas furnaces, but on the improvements a new furnace offers relative to the old one. Even more bizarre is the observation that the average number of stores visited/contacted by this group is 6.2, suggesting they did a reasonably thorough search for a furnace. One explanation consistent with these observations is that these people were not initially in the market for a gas furnace, but came to select one after being convinced it would be an improvement over their old system.

3.2.3. Socio-economic characteristics and Influential Factors

To complete our analysis of the reasons relevant to the selection process, we investigate the relationship between the specific household characteristics and the 9 most influential reasons. This analysis is based on the use of a logit model, where the dependent variable is whether or not the reason is selected as influential. The explanatory variables are the socio-economic factors defined earlier, as well as the following additional variables:

OCCUPANCY = Expected number of years to occupy dwelling
HDD = 30 year average annual heating degree days
NST = Number of stores contacted in shopping for furnace
EAST = 1 if located in east
WEST = 1 if located in west
SOUTH = 1 if located in south
TRG_2 = 1 if temperature set lower at night
CO1_N = 1 if old furnace not operating
POP_C = 1 if located in central city
ELD_P = 1 if any household member is 65 or older
YNG_P = 1 if any household member is under 6

We first estimated a general model with all of the 24 variables constructed at this point. For each reason, two alternative formulations of the dependent variable are used to examine the differences in a strong rating of 1-3 as compared to a more general top five rating. A summary of these estimation results is presented in Table 7. Columns one and two of this table indicate whether the null hypothesis that all variable coefficients are equal to zero can be rejected at the .05 and .01

Table 7. Summary of reasons for purchase analysis

		H_o: B = 0 .05	.01	P1	P2	R^2
DEALER	(1-3)	R	R	.84	.84	.13
	(1-5)	-	-	.58	.61	.05
OCCUPANCY	(1-3)	-	-	.90	.90	.08
	(1-5)	-	-	.51	.60	.05
ENERGY	(1-3)	-	-	.54	.58	.06
	(1-5)	-	-	.88	.88	.16
LOW	(1-3)	-	-	.79	.79	.03
FUEL	(1-5)	-	-	.60	.63	.04
LOW	(1-3)	R	-	.91	.91	.21
MAIN	(1-5)	-	-	.63	.66	.07
EER	(1-3)	R	R	.65	.65	.11
	(1-5)	R	R	.83	.85	.21
RESALE	(1-3)	-	-	.81	.81	.09
	(1-5)	R	-	.63	.63	.08
RELIABILITY	(1-3)	-	-	.83	.83	.06
	(1-5)	-	-	.70	.70	.08
HEAT	(1-3)	-	-	.82	.82	.09
	(1-5)	R	-	.70	.71	.09

R - reject hypothesis that B = 0
P1 - correct prediction % in sample with constant probability
P2 - correct prediction % in sample with model
R^2 - pseudo R^2 measure proposed by McFadden (1984) which measures the percent of variation explained by model relative to the percent of variation explained by a simple constant term.

confidence level, respectively. Based on these results the nine reasons are grouped in terms of whether they are systematically related to household characteristics as:

LIKELY - EER, DEALER

PLAUSIBLE - ENERGY, RESALE, HEAT

UNLIKELY - OCCUPANCY, LOW FUEL, RELIABILITY.

In general, the predictive content of these models is minimal as illustrated by columns P1 and P2 in Table 7.

A more detailed examination of the two reasons grouped as "LIKELY" indicates systematic variation within the 1 through 5 rating scale. The rating process is therefore modelled as a two stage procedure in which the reason is first selected and then ranked high (1-3), or low (4-5). Logit estimates for both stages of selecting and ranking the energy-efficiency rating are presented in Table 8.

The signs of the first stage estimates appear reasonable with factors such as low education, poor insulation, old furnace not operating and living in a trailer or multi-unit being associated with not selecting the EER reason Whereas, length of expected occupancy and number of stores contacted in furnace shopping are significant positive factors. The model's predictive content in sample as measured by P1 and P2 is fairly small, due in part to the large proportion, 83.5%, which chose the EER reason.

The ranking estimates in stage 2, also shown in Table 8, reveal some interesting correlations. Households in the west are more likely to rate efficiency high while households in the south are more likely to rate it low. High education of the spouse and household member (other than the

Table 8. Logit estimates of EER reason and ranking

First Stage, Selecting Reason

Variable	Coefficient	T-stat	Select = 1
low education (p)	-1.20	2.42	S1~X^2(17) = 15.3
poor insulation	-1.33	2.90	S2~X^2(7) = 48.6
trailer	-1.09	2.13	R^2 (McFadden) = .15
multifamily	-1.08	1.87	P1 = .835, P2 = .842
occupancy	.029	2.24	N = 418
number of stores	.21	3.09	
old furn. failure	-.69	2.10	
constant	.99	2.91	

Second Stage, Ranking EER Reason High/Low

Variable	Coefficient	T-stat	High = 1
South	-.36	2.04	S1~X^2(18) = 11.1
West	1.47	2.48	S2~X^2(6) = 27.8
high education (s)	.73	2.47	R^2 (McFadden) = .06
central city	-.49	1.76	P1 = .521, P2 = .625
over 65 (p)	-1.13	3.07	N = 349
over 65 (np)	.80	2.34	
constant	.11	.67	

S1 - Likelihood ratio test that coefficients of excluded variables (from set of 29 factors) are equal to zero.

S2 - Likelihood ratio test that coefficients of included variables are equal to zero.

p - panel member; s - spouse; np - non-panel household member panel) 65 or older both increase the probability of rating the EER reason high. Conversely, living a central city and panel member 65 or older are factors negatively related to ranking efficiency high.

Logit estimates for the Dealer Advice reason are presented in Table 9. Two factors, heating degree days and number of stores contacted, have a significant negative influence on both stages. The signs for both factors appear reasonable in that larger heating loads make it cost effective to search longer and rely less on dealer's advice. Two remaining factors important in selecting the Dealer Advice as an important reason are category variables for setting the thermostat lower at night and residing in the west; both have a negative coefficient. The results for the thermostat setting variable suggest that households that are either cost conscious or conservation minded are less likely to chose dealer's advice as an important reason for selecting their furnaces.

The other less significant factors in ranking the importance of this reason are low eduction of panel member, living in a central city, and residing in either the east or south. All of which are related positively to ranking the dealer's advice high among influential factors.

3.3. CONDITIONS AFFECTING THE PURCHASE DECISION

The remainder of the survey was designed to enhance our understanding of the selection criteria and process. As mentioned, the survey covers certain issues related to the purchase decision. Each of these issues was selected because it reflected on a particular aspect of the investment problem that pertained to one or more of the five viewpoints discussed in Chapter 2.

Table 9. Estimates of DEALER reason and ranking

First Stage, Selecting Reason

Variable	Coefficient	T-stat	
HDD	-.01	2.00	S1~$X^2(20)$ = 10.6
number of stores	-.06	2.03	S2~$X^2(4)$ = 16.1
lower night temp	-.40	1.81	R^2 (McFadden) = .03
WEST	-.84	1.89	P1 = .584, P_2 = .596
constant	1.42	4.0	N = 418

Second Stage, Ranking DEALER Reason High/Low

Variable	Coefficient	T-stat	
low educ (p)	1.14	1.66	S1~$X^2(18)$ = 9.5
central city	.87	2.46	S2~$X^2(6)$ = 30.2
HDD	-.01	1.79	R^2 = .12
number or stores	-.27	3.67	P1 = .721, P_2 = .742
SOUTH	.42	1.84	N = 244
EAST	.67	1.63	
constant	.03	.07	

S1 - Likelihood ratio test that coefficients of excluded variables (from set of 29 factors) are equal to zero.

S2 - Likelihood ratio test that coefficients of included variables are equal to zero.

p - panel member; s - spouse; np - non-panel household member

3.3.1. Emergency Purchases

We have already discussed some of the results related to the emergency nature of the purchase. To examine this issue further, we look at some possible differences between the respondents that said their old furnace was still operating and those that said it was not. Table 10 shows that there is little difference between the two groups with respect to selection criteria. Although there is some difference in the ranking, both groups share the same set of most influential factors.

Correlations greater than the absolute value of .2 for the operating group include installation costs and purchase price, energy efficiency and saving energy, and delivery and the unit being in stock. For the non-operating group, important correlations are similar, except we find also the negative correlation of delivery and energy efficiency. While this association is also significant for the operating group, the absolute magnitude is less than half of that for the non-operating group. Thus, it appears to be a relatively stronger association.

Finally, a logit analysis was performed to test the association of the operating variable with advice of a friend/neighbor/relative, in stock, energy efficiency, the brand name, and delivery. The in-stock, energy-efficiency, brand-name variables were found to be significant. The in-stock variable was negatively related to the operating group, while the energy-efficiency and brand-name variables were positively related. Thus, there is some evidence to support the traditional arguments regarding emergency buying and to distinguish this type of purchaser based on selection criteria.

Table 10. Influential factors for emergency purchases

Most Influential Factors	Operating-Group Ranking (N=165)	Non-Operating Group Ranking (N=474)
ENERGY	1	1
EER	2	2
RELIABILITY	3	3
LOW FUEL	4	5
HEAT	5	6
DEALER	6	4
Important Correlations*	**Operating Group**	**Non-Operating Group**
LOW INSTALL AND LOW PRICE	.32	.25
EER AND ENERGY	.34	.34
DELIVERY AND IN STOCK	.27	.31
DELIVERY AND EER	-.12	-.26

*All correlations significant at the .01 level or better.

A similar analysis was attempted with the respondents that said they purchased their new furnace because it was safer than the old one. Again, no differences in the major selection criteria could be found. Further, no criteria were found to be significantly related to the safety group.

3.3.2. A Conservation Ethic

To explore the implications of different energy-use factors on the selection criteria, we looked at the most influential factors for different levels of insulation. Some of the results from the analyses of conservation-investment attitudes suggest that past behavior is related to current decisions. Thus, we might expect that those with well-insulated homes are more likely to select the efficiency factors as important criteria. On the other hand, those with less well insulated homes have the most to benefit from high-efficiency furnaces. Looking at Table 11, we see that the rankings of influential factors are the same for the two groups. However, using a logit analysis, we find that the EER reason is positive and significantly associated with the well-insulated group. Such a finding supports the argument that past behavior may be a determinant of current attitudes and behavior.

Table 11. Comparison of insulation levels

Most Influential Factors	Well-Insulated Group Ranking	Adequate/Poorly Insulated Group Ranking
ENERGY	1	1
EER	2	2
RELIABILITY	3	3
LOW FUEL	4	4
HEAT	5	5
DEALER	6	6

3.3.3. Capital Cost and Credit

Respondents were asked about the purchase price of their new furnace. In general, respondents could give a figure for the purchase price but did not report a separate figure for the installation costs. Table 12 delineates the reported purchase prices and installation costs. The purchase prices for over a third of the sample falls in the $1000-2500 range. Installation costs are generally less than $500 for those who could distinguish a separate charge.

Related to the investigation of costs is the concern that credit is a significant factor in people's ability to afford a more efficient furnace. We asked if the furnace was purchased on credit. A large percentage of the sample (83.6%) said no while only 14.6% said yes. We also asked if financing considerations, e.g., the ability to obtain financing or afford monthly payments, were a barrier to buying a more expensive furnace. Ninety-one percent of the sample said no, while only 4.1% said yes. These results refute the argument that financing is a significant barrier to furnaces with higher purchase prices at least for our sample of respondents. Such evidence calls into question the efficacy of low-cost loan solutions that have been used by utilities and government agencies attempting to promote energy efficiency. However, our sample reflects consumers who actually purchased a replacement furnace; therefore our results are weakened by the fact that we do not have non-purchasers in the sample who may have desired a low-cost loan.

Table 12. Purchase price of new furnace

Purchase Price	%
Less than 600	11.7
601 - 800	9.1
801 - 1000	8.9
1001 - 1400	16.0
1401 - 1600	7.7
1601 - 2500	17.7
2501 - 5000	10.0
5001 - 7400	.3
No answer	18.62
<u>Installation Cost</u>	
Less than 200	14.9
201 - 500	14.2
501 - 1000	8.5
1001 - 7500	9.5
No answer	52.9

3.3.4. Shopping Efforts

Questions about the shopping and search activities of consumers were asked to see if the level of effort is related to selection criteria. Table 13 shows the sample percentages for time spent shopping and number of stores/dealers/showrooms contacted by either a visit or telephone. More than a quarter of the sample spent one day or less shopping for the new furnace.[4] Nearly two thirds made three or fewer contacts before the purchase decision. Given the cost information, these results tend to support the argument that consumers are not rational about the furnace purchase. One can easily imagine that consumers expend more effort looking for a $20 pair of shoes than for a new furnace.

Table 13. Shopping efforts

Variable	%
Time Spent Shopping	
One day or less	26.8
2 days - one week	15.0
8 days - 13 days	12.7
2 weeks - one month	19.7
More than one month	22.8
No answer	3.0
Number of Contacts	
1	37.1
2 - 3	25.8
4 - 6	26.6
7 - 10	7.7
More than 10	2.8

[4]Surprisingly, the less-than-a-week shoppers are not dominated by the emergency purchasers. A little more than half of the consumers with non-operating furnaces shopped for one week or less and visited three stores or less. In contrast, about 40% of the still operating group also spent a week or less and visited, on average, less than four stores.

We also find that over a fifth of the sample spent more than a month shopping for their furnace. Comparing these shoppers with the rest of the sample, we find that inexpensive maintenance costs were selected by a relatively higher percentage (Table 14). Looking at the influence of factors in a logit analysis, we find a significant and positive relationship between shopping for more than a month and three selection criteria; the recommendation of a friend/neighbor/relative, inexpensive maintenance costs, and the energy-efficiency rating.

Table 14. Comparison of "more than a month" shoppers with other shoppers

Most Influential Factors	"More than a Month" Shoppers	Other Shoppers
	(Rankings)	
ENERGY	1	1
EER	2	2
RELIABILITY	3	3
LOW FUEL	4	4
LOW MAIN	5	8
DEALER	8	6

3.3.5. Information about Energy Efficiency

To investigate the understanding and exposure to information about energy efficiency, we asked respondents a series of questions about the efficiency rating. In Table 15, we see that 62.9% of the respondents did not know the energy-efficiency rating of their furnace. Of the 204 who knew, the mean reported energy-efficiency rating is 87.8% with a standard deviation of 7.6%. However, because this is a figure that is easily forgotten after the selection is made, we also asked related questions to probe the understanding of the information. The majority of the sample told us that the energy-efficiency rating of the purchased furnace was consistent with the recommendation of the dealer. About 40% of the sample did not know.

Table 15. Consumer exposure to the energy efficiency rating

Variable	%
Energy Efficiency Rating	
Less than 62%	1.4
63 - 75	2.5
76 - 80	5.6
81 - 85	7.4
86 - 90	5.6
91 - 98	14.6
No answer	62.9
Is the rating consistent with the dealers recommendation?	
Yes	51.5
No	1.4
Did not receive a recommendation	10.2
Don't know	36.9
Was energy efficiency marked on furnace?	
Yes	38.7
No	13.8
Don't know	47.6
Offered Choice of Broad Range	
Yes	62.8
No	18.3
Don't know	18.9
Belief that Efficiency Rating is Credible	
Yes	50.4
No	6.7
Don't know	42.9

When asked if the energy-efficiency rating was marked on the furnace, 38.7% said yes, but more than that (47.6%) said they did not know. In contrast, the majority (62.8%) said they had been offered a selection of furnaces with a broad range of energy-efficiency ratings. Only 18.9% did not know an answer to this question. Finally, we asked about the accuracy of the energy-efficiency rating, because information not believed to be credible is unlikely to matter in the decision process or to be remembered. While we find the majority said they felt the energy-efficiency rating is an accurate indication of fuel usage, 42.9% did not know. Furthermore, the level of education of the panel member had no effect on the answer about the rating and fuel usage.

On the basis of these results, it appears that the energy-efficiency rating is a poorly understood characteristic of furnace options. We detect that people recall that their choice was consistent with something recommended by the dealer, but when pressed for more specific information, their recollection is limited. However, most people felt that they were shown an adequate selection of furnaces of varying efficiencies. This result could be related to the observation made earlier that there is a large number of furnace models from which to choose. A consumer could consider only a single manufacturer and feel exposed to a large number of alternatives.

3.4. HYPOTHETICAL-CHOICE RESULTS

The last part of the survey asks consumers to make decisions about hypothetical gas furnaces. First, we asked respondents to consider a furnace that has the same heating capacity as the one they purchased but an energy-efficiency rating of 65%. Table 16 shows these results. On the basis of reported efficiencies, we know that most consumers purchased a furnace with an energy-efficiency rating greater than 65%. In fact, the answers to the comparison are consistent with this; 44.6% of the sample thought the 65% efficiency furnace would cost less than the one they actually purchased. Looking at the expected differential, we see that a large proportion believed that such a furnace would cost $200 - 500 less. If the mean efficiency of the total sample equals that for the reporting group, the $200 - 500 range is very reasonable. Thus, we have some evidence that consumers perceive the efficiency-cost tradeoff correctly.

We also asked respondents to compare explicitly a low and high efficiency furnace on the basis of resale value to their home. We told respondents that the difference in purchase price was $500 for the two alternatives. We then asked them if they believed that the selection of the high-efficiency furnace would increase the sale price of their home if they were to sell it one year later. Fifty percent of the sample said yes, while only 30% said no (20% were no answer). When asked about the magnitude of the increase, 42.9 of the yes group said they believed it would be more than $500; 20.3% said it would equal $500; 21% said it fall between $250 and $499; 3.2% expected it to be less than $250; and 12.6% did not know. Thus, the majority of the respondents who perceived some resale value to the high-efficiency furnace also believed that this value would be close to, and might even exceed, the cost differential.

A third set of questions involving hypothetical choices was designed to help elicit consumer discount rates for furnaces. Dinan (1985) reports that estimates from the literature for space-heating equipment

Table 16. Comparisons with hypothetical furnaces

Variable	%	#
Comparison with 65% Furnace		
Would cost more	12.7	81
The same	26.3	168
Would cost less	44.6	285
Don't know	16.4	105
Differential for Cost-More Group		
Less than 200	22.2	
201 - 500	22.2	
501 - 1000	13.6	
1001 - 8000	30.9	
Differential for Cost-Less Group		
Less than 200	19.6	
201 - 500	35.8	
501 - 1000	16.5	
1001 - 4000	2.1	
No answer	26.0	

fall in the 3 to 28% range. Ruderman et al. (1986) argue that historically, discount rates for gas central-space heaters have been very high. They estimate aggregate market discount rates of 33.5%, 41.9%, and 45.1% for the years 1972, 1978, and 1980, respectively.

We structured our hypothetical-choice questions to illuminate the effects of uncertainty and capital-cost barriers. In the first case, respondents were asked to consider five alternative furnaces that differed in capital and operating costs. Annual operating costs were specified as uncertain, but to fall within a specific range for each furnace type. Type A was the least efficient furnace and type E the most efficient. In the second case, we used the same furnace information but removed all uncertainty (via a contract with the seller for fixed operating costs and a life-time warranty). Finally, in the third case, we repeated the certainty case (case 2) but offered 5% financing for a 48-month period so it would be possible for respondent to treat the capital cost as a monthly payment. In fact, at the 5% rate which is less than the interest rate paid on general savings' accounts over the study period, consumers should have found it very attractive to select the most efficient option because the operating-cost savings would have exceeded the incremental credit cost after the first year.

Table 17 shows the distribution of respondents over the five options for each case. The discount rates implied by options A-E are 25, 20, 15, 10 and 6 percent respectively. The results seem to indicate that discount rates fell from the uncertain to the certain cases (the proportion selecting options A - C falls, while the proportions selecting options D and E increases). We find similar results in the certain and

Table 17. Selection in hypothetical-choice problems

Choice Problem	% of Sample
Options with Operating Uncertainty	
A	15.8
B	6.1
C	24.7
D	18.3
E	23.3
No answer	11.7
Options Under Certainty	
A	11.1
B	4.7
C	22.2
D	20.7
E	23.5
No answer	17.8
Options Under Certainty with Low-Cost Loan	
A	9.4
B	4.4
C	21.1
D	19.2
E	24.3
No answer	21.6

low-cost-loan cases. It should be noted that the percentage of no answers also increased over options. Review of the survey forms indicated that a number of respondents did not feel comfortable with the low-cost-loan case because they were not interested in borrowing to finance their furnace purchase.

We can examine the switching behavior of respondents in the certainty cases to test further the rationality view. In particular we are interested in those who switched to option E, the most energy efficient option, when it was rational to do so. There are 26 respondents who selected option E in case 2 and then switched to something less efficient in case 3. There are 31 respondents who had something less efficient than option E in case 2 and switched to it in case 3. Overall, the majority (477 respondents) did not switch their case 2 choices in case 3. Of the 162 that did switch, exactly half switched to a less efficient option and half switched to a more efficient option.

In addition to indicating differences in discount rates, the hypothetical-choice problems may be indicating preferences for high-efficiency furnaces that are based on attitude differences. To test this, we use the three efficiency factors from the selection criteria to group our respondents. Group 1 respondents selected all three efficiency factors as most influential, group 2 selected at least two of these factors, and group 3 selected one or less.

Table 18 shows the frequency results for these groups in the third case. The percentages support the argument that strong preferences for the efficiency factors are associated with the perceived attractiveness

Table 18. Frequency distributions for option choices by group

Option	#	% of Sum	Sum	
No answer	8	0.09	85	
A	7	0.08		
B	3	0.04		
C	21	0.25		Group 1: three efficiency
D	19	0.22		factors selected
E	27	0.32		
	0			
No answer	45	0.18	254	
A	17	0.07		
B	13	0.05		
C	59	0.23		Group 2: at least two
D	57	0.22		factors selected
E	63	0.25		
	0			
No answer	85	0.28	300	
A	36	0.12		
B	12	0.04		
C	55	0.18		Group 3: at most one
D	47	0.16		factor selected
E	65	0.22		
	0			

of higher-efficiency options. In Table 19, we sum the option choices over all three cases (no answer=0, A=1, B=2, C=3, D=4, E=5) and compare means for the different groups. The means are significantly higher in groups 1 and 2 than group 3. In addition, the mean in group 1 is significantly higher than that of group 2.[5] These results support the contention that the efficiency factors are important indicators of either discount rates, or preferences for high-efficiency furnaces, or both. We return to this issue in the next section, when the group for which efficiency ratings were reported is examined.

Table 19. Mean scores for the sum of option choices

Group	n	Mean	Std. Error	Diff*	Std. Error*
1	85	10.34	.50	2.89	.56
2	254	9.35	.29	1.89	.39
3	300	7.45	.26	-	-

*Hypothesis of different means was tested using an auxiliary regression equation:

$$y_i = Co + \beta_1 X_1 + \beta_2 X_2 + \epsilon_i$$

where X_i are dummy variables for the group 1 and 2 observations.

The F-test of the null hypothesis $\beta_1 = o$ and $\beta_2 = o$ is significant at .01 level.

[5]The same analysis was conducted for each case, and we found the same general results for the means and differences.

3.5. SUMMARY

A number of useful conclusions can be drawn from this analysis of the total sample. To place the results in the context of the gas-furnace problem, we return to the different viewpoints of consumer efficiency-choice presented in Chapter 2.

Our results indicate that while there is an information problem in the selection of more efficiency furnaces, more information may not be an effective solution. Most of our respondents did not know the energy-efficiency rating of the unit they purchased. However, nearly two thirds felt that they had been offered a broad range of energy-efficiency ratings in the shopping process. Thus, more information may not be used even if it is made available.

The three most frequent and influential reasons for purchase are saving energy, efficiency rating and reliability of installer. Of the nine most frequent purchase reasons, efficiency rating appears to have the largest systematic or "explainable" portion, at least in terms of the variables we observe from the survey. Low education, poor insulation, emergency purchase and trailer or multi-unit dwelling are all significant factors for not choosing efficiency as an important reason. Significant factors associated positively with choosing the efficiency reason are length of expected occupancy and number of stores contacted. We find further that in ranking this reason for purchase, location (west, south, and central city) is important as well as the age composition of household members and education.

Advice of the dealer also exhibits some systematic relationships. Most importantly, this reason is negatively related to heating degree days and the number of stores contacted. Advice of the dealer was also negatively associated with inexpensive fuel and maintenance costs, suggesting that dealers may not be recommending high-efficiency furnaces. If consumers are particularly concerned about low operating costs, this would be consistent with the results on heating degree days.

The results for the other important reasons suggest that marketing approaches may not be very effective means to improve efficiency choices. However, we did find that there was a positive and significant relationship between the energy-efficiency reason and well-insulated homes, implying some support for the importance of past behavior and attitudes. Furthermore, an examination of the hypothetical-choice questions indicates that discount rates are probably less important to the purchase decision than attitudes about energy efficiency.

The capital-cost barrier viewpoint is not consistent with a number of our results. We find discount rates for a majority of the sample to fall into the 6 to 15% range, which is lower than that suggested by the literature. In addition, time horizons for over a third of the sample are between 10 and 20 years. A positive resale value for a relatively high efficiency furnace is perceived by 50% of the sample, and of this group, 43% believed it would exceed the cost differential. Finally, we found almost no evidence for our respondents that financing was a constraint for purchase price, in fact, the overwhelming majority of the sample indicated that they did not use credit at all for their furnace purchase.

We find mixed results for the rationality/irrationality viewpoint. For example, our results on the use of published information and the shopping effort support the view that consumers are not rational given the cost of the furnace. On the other hand, we reject the argument that this is largely an emergency purchase -- most people said their old furnaces were still working at the time of purchase. Where furnaces were still working, respondents were less likely to care about the unit being in stock and more likely to care about the energy-efficiency rating and brand name. All of this seems very rational. When asked about hypothetical furnaces, however, we find that, on average, there are as many respondents who choose rationally as those who choose irrationally.

4. ANALYSIS OF THE IDENTIFIED EFFICIENCY CHOICES

There are 213 of the respondents for which a reported brand name and model number matched an energy-efficiency rating from GAMA (1986) and (1987). We call this the identified group. A second group, for whom energy-efficiency ratings were self reported, we call the reported group. This group consists of 229 respondents. There are 105 respondents for which we have identified and reported energy-efficiency ratings.

The mean energy-efficiency rating for the reported group is 87.8% (standard deviation = 7.6). The difference between this group and the identified group is 8.36. The means are significantly different at the .01 confidence level, with that of the reported group exceeding that of the identified group. This suggests either people exaggerate the energy-efficiency rating slightly, their figures are not as conservative as those reported in the GAMA directories, or reporting the brand and model number information varied with efficiency levels (ie, those with lower efficiencies were less likely to report the efficiencies but reported the brand and model number so that we could identify their efficiencies).

We also tested the mean difference between energy-efficiency ratings for the 105 respondents where reported and identified figures were available. The mean difference for this group is 3.54 (standard deviation = 7.29), not significantly different from zero. In fact, the difference in the two ratings for 80% of the sample is less than 10% of the reported figure. Thus, in spite of the significant difference in means for the reported and identified groups, the reported figure appears to be a good indicator of the identified number. An explanation consistent with these results is that the 125 reported, but not identified, respondents bought more efficient furnaces, on average, and remembered the energy-efficiency rating but were less likely to give us enough information to identify their furnaces. Thus, if they remembered an efficiency number, respondents tended to be accurate. In general, we use the identified group for econometric analysis of the determinants of efficiency choice.[1] However, the combined group consisting of the 204 reported[2] and the 108 identified (but not reported) respondents is used to investigate further some of the issues raised in the analysis of the total sample.

4.1. HYPOTHETICAL AND ACTUAL EFFICIENCY CHOICES

We use the combined sample to revisit the issues raised in the analysis of the hypothetical-choice questions. In the previous chapter, we explored respondents' awareness about efficiency levels and cost differentials. Now with identified and reported efficiency levels, we are able to be more specific about the cost differential emerging from the comparison with the hypothetical furnace having a 65% energy-efficiency rating. Table 20 shows a cross tabulation for the difference in efficiency levels (actual level minus 65) and the mean cost differential. Respondents seem to be aware of a cost differential, and perceive increases in the cost with the larger differences in furnace efficiencies. A simple regression of the relationship yields (standard errors are in parentheses):

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[1]To understand the implications of limiting the sample, we analyze a bias equation for the restricted and total samples. These results are reported in part IV.b.

[2]We dropped 25 observations that did not have enough information to perform the analysis in Section IV.a.

$$\text{Cost differential} = \underset{(77.5)}{-124.9} + \underset{(3.46)}{26.3}(\text{efficiency difference}) \qquad \text{adj.}R^2 = .23$$

Table 20. Cost differential for comparison with 65% furnace

Difference in Efficiency	Mean Difference in Cost ($)	No. in Group[a]
-15.0 to -5.4	-950.00	1
-5.4 to 4.2	-273.10	13
4.2 to 13.8	150.00	22
13.8 to 23.4	240.00	73
23.4 to 33.0	576.30	80

Notes: [a]Total of number in group is less than 312 because of missing answers.

Next, we investigate the resale values perceived by respondents in the combined group. When asked if they believed that a cost differential between high and low efficiency furnaces would translate into a larger resale value for their home, 58% of the combined sample said yes and 42% said no. The mean efficiency for the no group is 78.7%, while the yes group is 5.4 percentage points higher and the difference is significant at the .05 level.

Among the 181 respondents who answered yes to the resale question, we could find no significant differences in mean efficiency levels for the resale-price differential. However, 47% of the yes group believed that the amount would exceed $500. The evidence suggests that higher reported energy-efficiency ratings are more likely to be associated with a positive belief about resale values. However, among consumers with a positive belief, the resale-price differential cannot be distinguished by the level of the energy-efficiency rating. The only conclusion that can be drawn is that a greater proportion of the positive-belief group also believes that the resale-price differential will exceed the cost differential.

Lastly, we look at the relationship among energy-efficiency rating, the efficiency factors, and the hypothetical-choice options. An additional variable is added to the combined group to distinguish energy-efficiency ratings above 85%. There are 135 respondents in the high-efficiency group. As with the total sample, we tested the option choices for differences associated with the group variables for the efficiency factors (group 1, 2, or 3 as defined in the previous chapter), and found similar results. Respondents from the combined sample selecting two or more of the efficiency factors as most influential also tended to choose more efficient furnaces in the hypothetical problems.

A cross tabulation of group variables and the high-efficiency variable is shown in Table 21. The column means indicate that respondents in the high-efficiency group had a greater percentage of group 1 types. A logit analysis of the high and low efficiency groups confirms this. Both group 1 and group 2 classifications are significant indicators of being in the high-efficiency group.

Table 21. Cross tabulation and logit analysis of high efficiency and group variables

Group	High Efficiency (≥85%) No	Yes
	(# in cell)	
1	20	30
2	74	75
3	83	30
Column Mean:	2.3	2.0

Logit Analysis:

Dependent Variable =
High Efficiency
1 = Yes
0 = No

Chi-Squared (2)	=	27.2
R^2 (McFadden)	=	.05
P1	=	.567
P2	=	.603
N	=	312.00

Variable	Coefficient	T-Ratio
Constant	-1.01764	-4.777
Group 1	1.42311	3.967
Group 2	1.03107	3.836

When we attempt to distinguish between high and low energy-efficiency ratings in the selection of the hypothetical furnace options, we find that group differences are not significantly different from zero (Table 22). Thus, implicit discount rates do not seem to differ across the high- and low-efficiency groups. This is curious since both the selection of more efficient hypothetical options and being in the high-efficiency group are positively related to group 1 and 2 types. However, these relationships are not transitive. Selecting more efficient hypothetical options is not associated with being in the high-efficiency group. This would support the argument that selecting two or more of the efficiency factors is not strongly correlated with discount rates (the primary factor revealed by the hypothetical-choice problems), but rather an underlying preference for higher efficiency furnaces (as revealed by actual choices).

Table 22. Mean differences in option-choice sums for high and low efficiency groups

Group	Mean	Standard Deviation	Difference	Standard Error
High	10.04	4.68	.82	.45*
Low	9.22	3.92	-	-

*Not significantly different from zero at the .01 level.

4.1.1. The Cost-Size-Efficiency Tradeoff

In addition to identifying the energy-efficiency rating from the brand name and model number information, we were also able to identify the heating capacity for 93 of the identified sample of respondents.[3] This information can be used to determine the cost-size-efficiency tradeoff faced by consumers in the sample. Table 23 shows that, in general, cost increases with size for any efficiency group, and cost increases with efficiency for any size group. In contrast, efficiency increases with the square footage of the heated portion of the home only for the largest size group. In that case, there is probably an income effect that is influencing the efficiency selection. The relationship among cost, size, and efficiency will be explored further in the next chapter.

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[3]Actually, we were able to identify sizes for 156 of the respondents but only 93 had enough information to demonstrate the cost-size-efficiency tradeoff.

Table 23. The cost-size-efficiency tradeoff

Efficiency (percents)		SIZE (1000 BTUs) 30-59	60-79	80-99	100-144	Total N
Low (50-79)	Square footage	1320	1739	1992	1632	
	Cost	1559	1665	1702	1386	
	Cost: std. dev.	1051	382	760	833	
	N	31	34	15	16	76
Med (80-89)	Square footage	1107	1680	1446	2200	
	Cost	1575	1755	1951	2745	
	Cost: std. dev.	631	778	838	1253	
	N	6	11	11	33	61
Hi (90-96)	Square footage	1496	1430	1542	3250	
	Cost	1661	1925	3875	2350	
	Cost: std. dev.	887	660	388	450	
	N	13	10	7	2	22
						93

4.2. STATISTICAL ANALYSIS OF THE EFFICIENCY CHOICE

4.2.1. The Bias Equation

The respondents in the identified sample group are used in an analysis of the determinants of the selected energy-efficiency rating. To understand the possible biases introduced by using a restricted sample rather than the total sample, we examine significant differences between the identified and total samples. A number of variables, drawn from both the socio-economic data and the selection 78 criteria, are used to test for sample selection bias. The variables used in the estimated sample selection equation are:

TRG_2 = 1 if temperature set lower at night
REC_Y = 1 if efficiency rating consistent with dealer's recommendation
MRK_N = 1 if efficiency rating was not marked on furnace
REP_2 = 1 if replacement furnace purchased between 3/1/85 - 2/28/86
CO3_2 = 1 if new furnace has different a efficiency rating from the old one
EFFK = 1 if efficiency is not reported
INC_H = 1 if household income in 1986 is 40,000 or higher
GPRICE = average state price of natural gas to residential consumers during the 1985/1986 heating season

as well as four of the reasons for purchase:
Recommendation of a friend/relative/neighbor (FRIEND), Unit in Stock (IN STOCK), Energy-Efficiency Rating (EER), and Brand Name (BRAND).[4]

The objective in formulating variables such as EFFK and MRK_N is to test whether a higher level of awareness about energy-efficiency information is present in the restricted sample.

The estimation results shown in Table 24 indicate that the aware respondent is significantly more likely to be in the identified sub-sample (coefficients on EFFK and MRK_N are significant). We also note

[4]In fact, we tested all the reasons for purchase in the bias model but found only these four to add significantly to the bias model.

Table 24. Logit estimates of sample selection equation

Variable	Coeff.	T-stat	Subsample = 1
Constant	-3.67	4.75*	$\chi^2(12) = 81.91$ pseudo $R^2 = .103$ P1 = .68, P2 = .69 N = 639
TRG_2	.22	1.16	
REC_Y	.34	1.72	
MRK_N	.59	2.31*	
REP_2	-.47	1.49	
CO3_2	1.08	4.12*	
EFFK	-.42	2.31*	
INC_H	-.46	2.18*	
GPRICE	.26	2.34*	
FRIEND	.44	1.83	
IN STOCK	.66	2.23*	
EER	.48	2.43*	
BRAND	.65	2.75*	

Notes: *Statistically significant at the .05 level or better.

that the estimated marginal effect of income (negative and significant) and natural gas prices (positive and significant) are consistent in that both imply a higher relative share of income is used to pay the cost of heating. Expending a relatively larger share of income on heating costs is likely to make people more sensitive to the furnace purchase and thus also increases the probability of being in the sub-sample. Similarly, the positive and significant results on the reasons for purchase indicate that respondents in the identified sample are more aware of the unit-specific information regarding their furnace choice.

Possible selection bias in estimating an efficiency choice equation is addressed using the method proposed by Heckman (1979). The estimates of the sample selection equation are used to calculate the inverse Mill's ratio, denoted lambda, which is included as an additional variable in an ordinary least squares model of efficiency choice. The coefficient of lambda provides an estimate of the error covariance between the selection and choice equation. The corresponding t-statistic is thus a Wald test of whether selection bias is an issue in modelling efficiency choice.

4.2.2. <u>Selecting an Energy Efficiency Level</u>

The estimation results for several alternative model formulations of the selected energy-efficiency rating are presented in Table 25. We first developed a model using the household characteristics previously discussed. Estimates of this model are shown in columns OLSA and SSA in Table 25. A comparison of these columns reveals that correcting for selection bias does not greatly influence the parameter estimates. Furthermore, examination of the sample selection issue reveals the key role of the awareness proxy variable EFFK. Column SSC demonstrates the

Table 25. Model estimates of efficiency choice*

	OLSA	SSA	OLSB	SSB	SSC
Constant	76.52 (27.14)	86.43 (25.28)	73.41 (25.91)	80.22 (21.47)	80.44 (22.91)
HDD	.11 (2.68)	.09 (2.51)	.12 (3.11)	.11 (2.99)	.09 (2.72)
NST	-3.03 (4.66)	-2.88 (4.75)	-2.55 (4.14)	-2.55 (4.35)	-2.47 (4.46)
NST_S	2.39 (4.05)	2.31 (4.21)	2.05 (3.70)	2.07 (3.91)	1.91 (3.83)
ED2_H	4.59 (2.84)	4.15 (2.74)	3.65 (2.40)	3.53 (2.44)	2.78 (2.03)
INC_H	3.14 (2.30)	3.16 (2.49)	1.36 (1.04)	1.76 (1.40)	.47 (.39)
ELD_P	4.07 (3.22	3.82 (3.24)	3.13 (2.62)	3.16 (2.77)	3.39 (3.16)
EAST	-3.22 (2.04)	-3.62 (2.45)	-2.57 (1.73)	-3.00 (2.10)	-2.02 (1.49)
SOUTH	-7.44 (4.09)	-7.72 (4.58)	-6.48 (3.81)	-6.81 (4.21)	-4.66 (2.94)
REASONS			**	**	**
EFFK	-- --	-- --	-- --	-- --	-7.32 (5.30)
LAMBDA	-- --	-9.12 (4.51)	-- --	-5.53 (2.63)	-1.39 (.65)
R^2 =	.32	.38	.42	.44	.51
ADJ(R^2) =	.29	.35	.39	.41	.47
K =	9	10	13	14	15
N =	203	203	203	203	203
SE =	8.35	7.76	7.56	7.38	6.95
CSE	--	9.76	--	8.19	7.01
ρ^2 =	--	.89	--	.46	.04

CSE = Standard error corrected for selection bias.
 * T-stat in parentheses.
** Reasons for purchase included in estimated model, see next page.

Table 25. Model estimates of efficiency choice (cont'd)

REASON	SSB[1]	SSB[2]	SSC[3]
FRIEND	2.25 (1.62)	2.33 (1.61)	2.77 (2.11)
LOW PRICE	-3.24 (2.24)	-3.44 (2.30)	-4.07 (2.96)
SIZE	-3.82 (2.53)	-4.05 (2.55)	-3.69 (2.58)
EER	3.73 (3.03)	2.98 (2.16)	2.94 (2.51)
Sum of Squared Residuals	10290	9326	9085
Number of Regressors	14	28	15

1 Estimates of Model SSB with all 18 major reasons for purchase included, only the four significant reasons are shown here for comparison purposes.

2. Re-estimation of SSB with only four reasons listed. The test statistic for the hypothesis that the other 14 reasons have a zero coefficient is .26 distributed as $F(14,28)$. In addition, coefficients on significant four reasons are robust.

3. SSC = SSB + EFFK.

effect of including this variable in the selection equation. The cross equation covariance, the coefficient of lambda, is not significantly different from zero. Of course, this specification is somewhat specious in that choosing an efficiency level precedes recalling the selected level. However, we have already argued that EFFK and lambda are closely related to awareness of the furnace characteristics. The results from model SSB and SSC indicate that the bias problem is more related to an unobserved awareness variable. Thus, inference from our coefficient results is likely to be correct, if not as precise as that which would be obtained from the larger sample.

Many of the results in model SSA are what we would expect. Heating degree days (HDD) have a positive and significant effect on the selected energy-efficiency level. Higher education (ED2_H), in this case of the spouse,[5] increases the selected level as does higher income (INC_H). The results on higher income, however, are not robust across the model specifications that include the reasons for purchase. The presence of a household member older than 65 (other than the panel member) also increases the selected efficiency rating. The two division variables, EAST and SOUTH reveal a negative and significant difference from the CENTRAL division.[6] Since we have already corrected for HDD, the results suggest that attitudinal differences exist across regions, although, only

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[5]We tried a number of education variables, including a combined educational level, but always found that only the education of the spouse was significant.

[6]A WEST division variable was also included in initial estimation of this model but was always insignificant. However, this result may be somewhat artificial since the efficiency choices for respondent living in California are constrained to be greater than 80% by state law.

the SOUTH variable is robust when we consider reasons for purchase. Furthermore, a number of obvious variables such as heated square footage of the home, gas prices, and discount rates were tried in the model, but found to have no significant effect on efficiency levels.

A surprising result is that the greater the number of stores contacted in the shopping effort (NST), the lower the selected energy-efficiency rating. We considered that this might vary with the intensity of the shopping effort, as greater number of stores contacted could lead to an overload of information. A new variable, NST_S, defined as the number of stores contacted if a week or more was spent shopping is included to test whether the marginal effect of shopping is related to the length of time spent shopping, i.e., the intensity of the shopping effort. The estimates indicate that the effect of shopping does significantly change with length of time spent, from -2.88 to -.57,[7] if a week or more is spent shopping.

If we replace the NST and NST_S variables with NST_S and NST_F (the interaction between the indicator for less than a week shopping and NST), we get the direct results on the intensity of the shopping effort. Using the same basic model as SSB, the coefficient on NST_F is -2.55 and the coefficient on NST_S is -.48 (both significant at the .01 confidence level). This indicates that the marginal effect of another store is to lower the selected energy-efficiency level, regardless of the shopping intensity. However, the magnitude of this marginal effect is nearly 5 times as large if the shopping intensity is fast rather than slow.

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[7]This is calculated from -2.88 + 2.31 = -.57. However, a separate regression is necessary to conclude that combined result is significantly different from zero.

The shopping results support the argument that consumers may be more confused by the available information regarding furnace alternatives than actually helped by it. In fact, what they probably learn by using more stores is that there is an incredibly large range of furnace efficiencies and sizes. They may be relying on the competitiveness of the market to drive out the "lemons",[8] thus, believe that their discovery of so many lower efficiency furnaces is an indication that higher efficiency are not worth the price.

The 18 most frequently cited reasons for purchase are included in the model to determine their importance in choosing an efficiency rating. Estimates of this extended model are reported in the column SSB with only the four significant reasons included. The F-test statistic that the coefficients of the other 14 reasons are zero is .23, so that the null hypothesis that the influence of these reasons is not significantly different from zero cannot be rejected at any minimal confidence level.

The results are consistent with the previous reason for purchases analysis. In particular, the results for an inexpensive purchase price, the physical size (implying installation constraints), and the efficiency rating are all in the expected direction. However, the magnitude of the result on efficiency rating is certainty not outstanding, given the obvious connection between this variable and selected levels.

The recommendation of the friend/relative/neighbor leads to selection of a higher efficiency level. This suggests that either information about lower heating bills is being transferred or certain

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[8]Akerlof (1970) makes the argument that consumers may think the same thing about the car market.

conservation attitudes are being promoted. Note that the advice of the dealer was one of the 14 reasons that did not affect the selected energy-efficiency level.

4.3. SUMMARY

Our analysis of reported and identified energy-efficiency ratings helps clarify some of the results from the previous chapter. Although we do not have the energy-efficiency rating data on all 639 respondents, we are able to characterize the bias in the more limited sample. We find that the bias is related to awareness of the furnace features. Our identified sample has a greater share of respondents who are more likely to know their energy-efficiency rating, and more likely to pay higher shares of their income in heating bills. However, this bias seems to affect largely an unobserved, rather than observed, variable in the energy-efficiency selection model. Thus, the bias is a problem for the precision of our estimates and not the inference of the model for the total sample.

Using a combined sample of reported and identified energy-efficiency ratings, we find that respondents correctly perceive the cost differential for more efficient furnaces. This finding is contrary to the information viewpoint. Furthermore, the results of the analysis of the shopping effort suggest that more information may not lead to selection of more efficient furnaces. In fact, the consumer either may be facing too much information or concluding from the available information that lower efficiency furnaces are a better buy.

In contrast, the marketing viewpoint is supported by our results on the comparisons between high-efficiency and low-efficiency groups that indicate selections are related to beliefs about resale and the three efficiency factors. However, these relationships are not robust in the presence of other factors. The same is true for most of the socio-economic variables with the exceptions of income, education of the spouse, and location in the south.

The irrationality viewpoint is consistent with the finding that some of the variables more closely associated with rational decision making, e.g., square footage of the heated portion of the house, gas prices, and discount rates, are not significant in the efficiency-choice model. Only the heating degree days, presence of someone 65 or older, and the four significant reasons for purchase can be reconciled easily with the economic-man framework. These issues are expanded further in the next chapter.

5. ANALYSIS OF ECONOMIC MAN

The analysis of the efficiency-choice model provided a descriptive account of how consumers select efficiency levels. In this section, we explore the choice from a normative perspective and ask whether or not respondents' choices are rational. We determine the rational choice by using a naive model of economic man, where the objective is to minimize the total discounted cost of heating, given respondent-specific heating needs and general price information for capital and fuel costs.

As an additional check on rationality, we test the hypothesis proposed by Friedman (1987). He argues that differences in indoor and outdoor temperatures lead to certain choices in insulation and efficiency levels which, in turn, affect optimal temperature settings. Good insulation and efficient furnaces in Chicago make the marginal cost of an additional degree for indoor temperature less than that for Los Angeles, where rational people buy relatively less insulation and less efficient furnaces. Thus, we have the paradox that homes in Chicago are kept warmer than homes in L.A., even though the average heating cost is less in L.A.

Friedman's argument is based on the assertion that the marginal cost (dependent on fuel cost, insulation and efficiency levels) is less in Chicago. Recall from our analysis of efficiency choice, that selected levels did in fact vary positively with heating degree days. Since we have data on temperature settings, efficiency choices, insulation levels, and heating requirements, we can test the Friedman hypothesis for our combined sample of 332 respondents.

5.1. THE ASSUMPTIONS FOR ECONOMIC MAN

To establish a comparative basis for the efficiency-choice problem, we combine information that is respondent-specific with market data in a discounted net present value framework. Figure 2 shows the various inputs to the economic-man model and process of analysis. Respondent-specific information includes the discount rate, the time horizon, and annual heating requirements. We have 128 respondents for which all the necessary information was available. Market data includes fuel prices and a schedule of capital costs for furnaces of two size levels and three efficiency levels. Combining both types of data, we estimate the efficiency choice that minimizes discounted costs for each of the 128 respondents as if they had behaved as the simple economic man.

The basic cost equation is:

$$DTC = C(AFUE) + \sum_{0}^{T} [PG \times (AHL/AFUE)] \ / \ (1+DR)^{t}$$

where:
- DTC = discounted total cost;
- PG = the 1986 price of natural gas by state;
- C(AFUE) = the capital cost of the furnace
- AHL = the annual heating load;
- AFUE = the annual fuel utilization efficiency;
- DR = the discount rate;
- T = the time horizon.

We used this model to estimate DTC for AHL and to test the sensitivity to heating loads, the set point heating load (SPHL). We make the assumption that annual heating requirements are constant throughout the time horizon. Notice that both the capital cost and the operating costs are assumed to vary with the AFUE. Size also affects capital cost, but because we have data for only two size levels, we mapped respondents into a particular size group and then solved for efficiency. The size

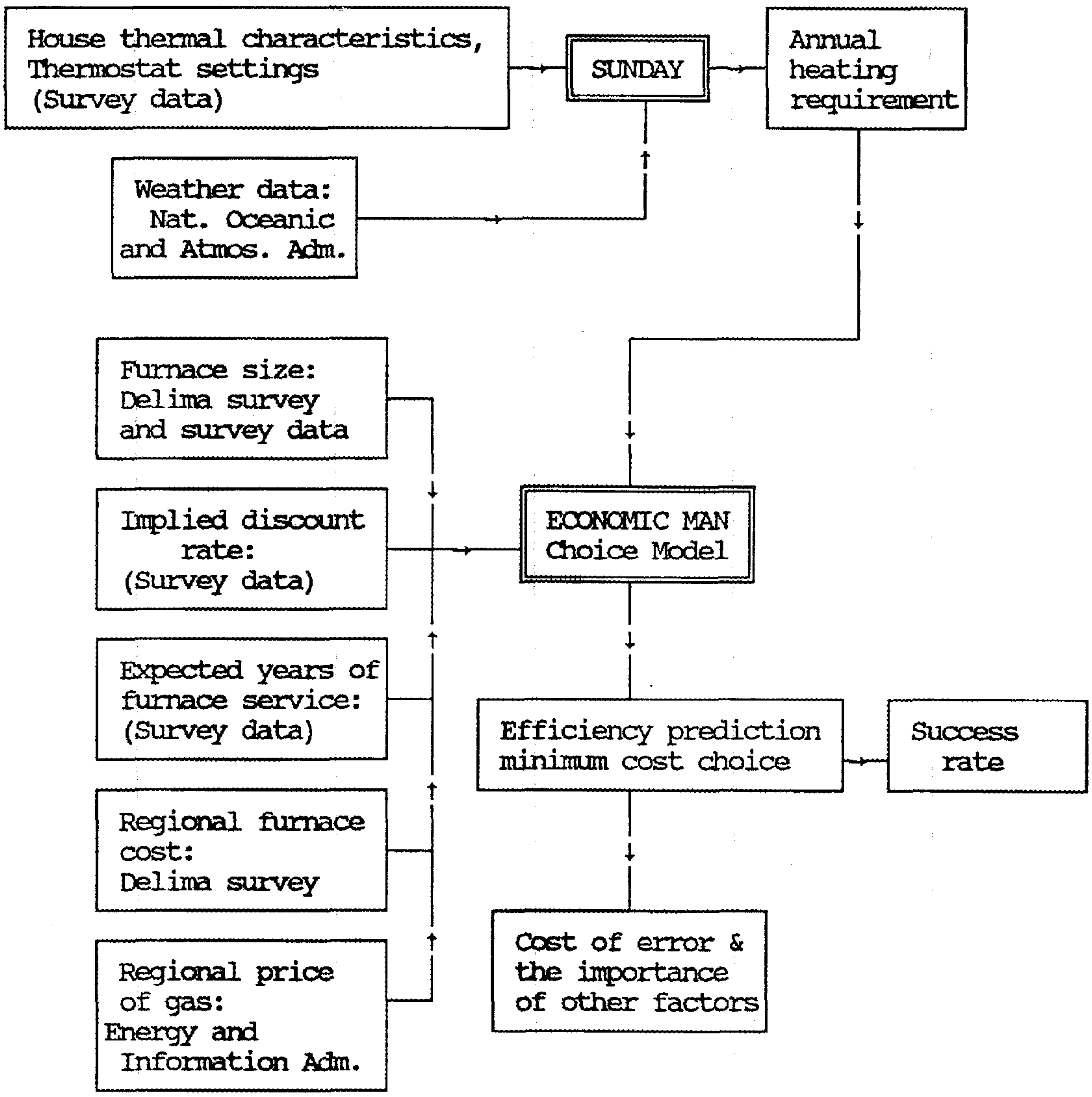

Fig. 2 Flow diagram for the economic-man model

group is based on the house characteristics and weather conditions. We believe this rule of thumb is consistent with the actual sales practices in the market.

The discount rate and time horizon are taken directly from the survey responses. We ran the model under the discount rates elicited from both the uncertain and certain operating costs cases from the hypothetical-choice problems. In the cases where either the time horizon or discount rate was missing for a respondent, we used 10 years and 12.5%, respectively.

The annual heating requirements were calculated using the SUNDAY[1] computer program. Because many of the SUNDAY parameters such as window area and heat loss rate[2] were not available from the survey responses, we used average estimates for the US. For heat loss, we used the following heat loss rates (BTU/degree day/sqft): 3, 8, 15 corresponding to a well insulated, adequately insulated, and poorly insulated house, respectively. For window area, we used 15% of the square footage and divided it equally to four sides of the house. Using the SUNDAY program, we generated the AHL and SPHL for the 128 observations. The SPHL exceeds the AHL by the amount of heat derived from solar gains, internal gains (from bodies and appliances), and heat storage (Ecotope 1984).

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[1]SUNDAY is a building heating-load simulation program that uses information on square footage, insulation levels, window area, weather data, and building materials to estimate annual heating loads. The program is published and distributed by Ecotope, Inc.

[2]The heat loss rate measures the escape of heat from the envelope to the outdoor air through either conduction or convection (Eklund and Baylon 1984).

The price of gas, by state, was obtained from the Energy Information Administration of the Department of Energy. We had both 1986 and 1985 prices but used the 1986 prices to do the basic calculations. We assume initially that prices are expected to remain constant at the 1986 levels. Later, when we reconcile actual choices with those of the economic-man model, we consider the price expectations reported by respondents.

The capital cost and furnace size data were obtained from Henry Delima of Delima Associates in California. He recently completed a review of installed furnace prices by region using 22 cities in the US. The review included direct interviewing with dealers for a single brand of gas furnace, with a minimum of 12 and a maximum of 48 price quotes in any one city. The brand that was selected for the review represented a medium-priced brand that is nationally available. In addition, the review was limited to the two most common furnace sizes, 75,000 and 90,000 BTU/hr. Table 26 shows the capital cost data by region. These prices tend to be lower than the corresponding prices from our respondent data (recall Table 23), but our standard deviations are fairly large.

To size the furnace for the economic-man sample, we use the formula reported in Eklund and Baylon (1984):

$$\frac{(SPT - DT) \times HLR(INS, SQFT)}{SSE} = \text{Output rate (BTU/hr)}$$

where: SPT = the set point temperature;
DT = the design temperature;
HLR = the heat loss rate as a function of insulation and square footage;
SSE = the steady-state efficiency rating.

The set point temperature is the highest indoor temperature setting. The design temperature is that outdoor temperature which is exceeded at least

Table 26. Total installed cost based on regional data

Region	Efficiency[a]	Size	
		75,000 BTU	90,000 BTU
New England	Low	1220	1300
	Med	1560	1690
	High	2460	2650
Mid Atlantic	Low	1370	1590
	Med	1700	2070
	High	2350	2700
South Atlantic	Low	1280	1500
	Med	1660	1850
	High	2600	2650
E. North Central	Low	1330	1350
	Med	1680	1760
	High	2480	2360
E. South Central	Low	1210	1410
	Med	1530	1680
	High	2210	2460
W. North Central	Low	1200	1380
	Med	1430	1720
	High	2170	2430
W. South Central	Low	1030	1290
	Med	1170	1560
	High	2180	2480
Mountain	Low	1170	1310
	Med	1420	1650
	High	2090	2390
Pacific	Low	1380	1480
	Med	1770	1930
	High	2480	2810
Average (All Regions)	Low	1243	1407
	Med	1547	1768
	High	2336	2548

Notes: [a] Low = 70-79% efficiency, Med = 80-89%, High = 90-98%.

Source: Personal correspondence with Henry Delima at Delima Associates, January 15, 1988.

99% of the heating season (matched to respondents by city). The steady-state efficiency rating indicates fuel usage excluding cycling losses. The resulting number is usually multiplied by 1.5 to 2 as a margin for error. As is clear from the formula, this is not a very precise measure unless the HLR is calculated so as to accurately represent the heat loss of the house.[3] In most cases, rules of thumb are used for the calculation, hence, the adjustment for error.

Using the sizing equation above, we calculate the output size under a number of different assumptions. First, we use the energy-efficiency rating selected by the respondent[4] and multiply the calculated level by 1, 1.5, and 2 corresponding to the three error factors. For the economic-man comparison, we use the lowest average energy-efficiency rating (75%) for which we have market data and then calculate the level under the three error factors.

On average, we find that reported units are oversized when we use the energy-efficiency rating selected by the respondent. The mean differences for the sample are 51.4 (std. dev. = 25.5), 37.8 (std. dev. = 31.9), and 24.2 (std. dev. = 40), for error factor 1, 1.5, 2, respectively. Only the results corresponding to the error factor of 1 appear to indicate a systematic bias to oversize furnaces. However, looking at the distribution of the mean differences in Table 27, we see that they are in fact skewed to values greater than zero. Using the 75%

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[3]In fact, this can be done from data on insulation and building materials in the house such as might be collected in an energy audit.

[4]This assumption will lead to a positive bias in the output levels since our energy-efficiency ratings are less than the SSE. However, as we discuss later, most of the selected furnace sizes exceed our calculated levels in spite of the bias.

efficiency rate and the 1.5 error factor, we find very similar results to suggest oversizing. The mean difference is 40.4 (std. dev. = 29.8) but the distribution is highly skewed to the positive values.

Table 27. Distribution of differences between estimated and selected furnace sizes

Error Factor		Difference									
		-100	-75	-50	-25	0	25	50	75	100	125
1	N:	0	0	0	1	1	17	43	46	13	7
1.5	N:	0	1	0	3	12	13	62	24	10	3
2	N:	2	1	4	7	13	20	56	18	5	2

5.2. THE OPTIMAL CHOICE FOR ECONOMIC MAN

Optimal choices given the price data and the DTC equation are calculated for four cases. Case 1 uses the SPHL and the uncertainty discount rate (from option 1); case 2 uses the SPHL and the certainty discount rate (option 2); case 3 uses the AHL and the uncertainty discount rate; and case 4 uses the AHL and the certainty discount rate. Recall that the uncertainty discount rate generally equalled or exceeded the certainty rate.

Table 28 shows how well the economic-man model predicted the energy-efficiency ratings selected by the respondents. In all cases, less than

Table 28. Performance of economic-man model under four cases

	Case (both furnace sizes)			
	1	2	3	4
# Non-match[1]	84	84	67	69
# Match	44	44	61	59
	(only 75,000 BTU furnace size)			
# Non-match	72	72	55	57
# Match	40	40	57	55

Notes: [1]Non-match with respondent's selected efficiency level.

half of the actual choices correspond to the economic-man choices.[5] Futhermore, there is very little difference between cases 1 and 2 as well as between cases 3 and 4, suggesting that differences between the certainty and uncertainty discount rates are not important. Additional analysis of the 75,000 BTU size for cases 1 and 3 revealed that there were 47 observations where neither case matched, 32 observations where both cases matched, 25 observations where case 3 matched but case 1 did not, and 8 observations where case 1 matched but case 3 did not. Thus, case 3 performs the best relative to the other cases, probably because most people use an uncertainty discount rate and heating loads more consistent with the AHL than the SPHL.

Using the case 3 assumptions and the AHL, we examined whether or not the economic-man model over or under estimated the "optimal" efficiency level for each respondent.[6] Figure 3 shows the predictive content for the model. There were 56 observations (or 48% of the sample) for which the model predicted the efficiency level that was actually purchased by the respondent. The model predicted a higher efficiency level than what was actually purchased for 14 respondents (or 12% of the sample). Finally, the model predicted a lower efficiency level than what was actually purchased for 47 respondents (or 40% of the sample). On

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[5]In some of the analysis we concentrated only on the 75,000 BTU size since this was the appropriate size for the majority of analyzed respondents and the economic-man model performed much better for this size. Later, when we look at the reconciliation of choices, we use the 128 observations.

[6]This more detailed analysis revealed that there were a few respondents that actually purchased gas boilers. Because the constraints on the gas-boiler choice are somewhat different from that of the forced-air furnace, we eliminated these observations from further consideration.

		Predicted Efficiency			
		L	M	H	
Actual Efficiency	L	49	10	4	63
	M	18	7	0	25
	H	24	6	0	29
		91	22	4	117

14 Over Estimated

47 Under Estimated

Fig. 3 Economic-man model predictive content average, the model tends to have a selection bias towards low-efficiency furnaces.

We can use the model to compute what we call the cost of error, i.e., the present value of the cost differential between the optimal efficiency level and the level selected by the respondent.[7] Table 29 shows that the cost of error is greater for the under estimated cases than for those where efficiency was over estimated. Thus, at least for this sample, the average cost of not matching economic man was greater for consumers that bought a higher efficiency furnace than the model predicted.

Table 30 shows the distribution of the respondents with respect to matching the economic-man model, and in cases of a non-match, with respect to being explained by other information. Efficiency selections by 62 of the 117 respondents match the ratings that are optimal for the economic-man model.[8] Other information to reconcile choices is tested sequentially, i.e., we first test if the respondents reported a capital cost that rationalizes the efficiency choice, then we examine whether or not oversizing rationalizes the choice, and so on. Once a respondent

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[7]The net present values here have been calculated using the respondents discount rate and not a single social rate for all respondents. Thus, this is the net present value from the respondents' point of view, and the values for two respondents are not directly comparable. An appropriate interpretation of the results is that while respondent 1 incurred a cost of error equal to $1000 from his/her perspective and respondent 2 incurred a cost of $1000, the correct social cost of these decisions is not $2000. Rather than using respondent discount rates, we could have argued that the appropriate discount rate for economic man is the social rate of time preference, historically equal to 2-5% in real terms. However, our intent here was to see if the respondent was minimizing DTC given his/her perspective.

[8]Actually, 56 matched and an additional 6 respondents incurred costs of error less than $100.

Table 29. The cost of error

NPV of Cost	All Cases	Under Estimated	Over Estimated
0	56	—	—
100	6	1	5
500	27	22	5
1000	13	12	1
>1000	15	12	3
Total	117	47	14

Table 30. Rationalization of respondents choices

Rationalization	Under Estimated	Over Estimated
<$100 for the cost of error	1	5
Good Deal	13	0
Oversized	0	3
Gas Price Expectations	7	3
Increases house value >$500	11	0
Reasons ENERGY & EER ranked 1-5	9	0
Reasons ENERGY or EER ranked 1-5	4	0
Unexplained	2	3

has been reconciled with the economic-man model, they are removed from consideration of the next rationalization. Subsequently, some of the numbers in the rationalization cells may change if we reorder the sequence, e.g., place gas-price expectation before "good deal."

There are 13 respondents who reported purchase prices so low that their selected efficiency levels are considered motivated by a "good deal." Note that this explanation assumes the same good deal would not be available for alternative efficiency levels. Thus, we are assuming the consumer considered the low price on the furnace actually purchased, but faced market prices on furnaces not purchased. All of the respondents explained by the good deal purchased furnaces that were more efficient than the model's prediction.

Three people clearly oversized their furnace. In fact among all the non-matches, we found 11 people who oversized, relative to the size we assigned them, and paid more than $100 in additional discounted costs. However, this tends to greatly understate the sizing problem because the smallest size we were able to assign is 75,000 BTU which already implies an oversizing error.

Ten people were reconciled when we considered their gas-price expectations reported in the survey. If they expected gas prices to rise (fall) faster than general inflation, we used a real escalation rate of 2% (-2%) in the DTC calculation for economic man. Eleven people that had purchased a more efficient furnace than predicted by economic man also believed the resale value on a high-efficiency furnace would exceed the cost differential. Nine others bought a higher efficiency and had selected both saving energy and the energy-efficiency rating in their most important reasons for purchase. Four others also purchased a more efficient furnace, and had selected one of these two efficiency criteria in their most important reasons. Thus, these respondents are reconciled with the economic-man selection by exhibiting a preference for energy conservation.

Upon exhausting what we consider to be the most obvious rationalizations, we are left with 5 respondents that cannot be explained. Two of the five did not report selection criteria, but we know one of them suspected the old furnace was about to break down.

To understand the remaining three and their choices, we examined their five most important criteria and their reported operating condition of the old furnace. One person had received a rebate from the manufacturer, but in spite of this, we do not consider that he/she received a good deal. One person appears not to have considered energy factors at all, no efficiency reasons are listed in the most influential factors and he/she purchased a 67% efficient furnace. Finally, our remaining respondent reports selection criteria consistent with purchasing a high-efficiency furnace but he/she actually selected a 68% efficient furnace.

5.3. A TEST OF THE FRIEDMAN HYPOTHESIS

Friedman (1987) argues that indoor temperature settings are rationally related to insulation levels and energy-efficiency ratings for heating equipment. He contends that consumers that live in colder climates have lower marginal heating costs than those that live in relatively warmer climates. The lower marginal costs result from insulation and equipment efficiency choices that are positively related to the differences between indoor and outdoor temperatures. Thus, although seemingly a paradox, it is rational for consumers in cold climates to set their indoor temperatures higher than the settings of similar consumers in warm climates. This argument leads to a number of testable hypotheses given our data set.

Looking at regional temperature settings, we can illustrate the paradox using a sample of 332 of our respondents (Table 31). We find the mean heating degree days (HDD) vary significantly relative to the central region, and the mean temperature settings support the paradox. However, we cannot reject the null hypothesis that the differences (relative to the central region) in temperature settings are not significantly different from zero in this simple analysis of means.

To test the hypothesis more fully, we construct a model of temperature setting and the factors considered by Friedman. We have already shown that efficiency choices are positively related to heating degree days. In addition, by an analysis of means, we argued that owners of well-insulated houses tended to select higher energy-efficiency ratings for their furnaces, although this relationship was not robust in the efficiency-choice equation. Both of these results are consistent with Friedman's argument.

We consider the following models:

F1: DAY = F1(CONSTANT, INS_1, EFF1, HLR, PRICE86) + e_1

F2: DAY = F2(CONSTANT, INS_1, EFF1, HLR, PRICE86, EAST, WEST, SOUTH, DWL_1, ELD_P, AG1_0) + e_2

where: DAY = the daytime indoor temperature setting;
EAST, WEST, SOUTH = regional indicator variables;
INS_1 = an indicator for a well-insulated house;
DWL_1 = an indicator for a trailer or mobile home;

Table 31. The temperature-setting paradox

Region	HDD (mean)	N	Mean Temperature Setting (Day)
Central	6579	170	69.18
East	5955[a]	54	68.31
South	3487[a]	62	68.98
West	4578[a]	46	67.93[b]

[a]All significantly different from Central region at .01 confidence level.

[b]Weakly significantly different from Central region (T-stat = 1.85), all other regions are <u>not</u> significantly different from Central.

ELD_P = an indicator for the presence of a person 65 or older other than the panel member;
AG1_O = an indicator if the panel member is 65 or older;
HLR = the heat loss rate of the house;
EFF1 = the reported, or if not reported then identified, energy-efficiency rating of the selected furnace;
PRICE86 = 1986 natural gas prices by state.

According to Friedman's theory, we expect a positive relationship between DAY and INS_1 and EFF1, and a negative relationship between DAY and HLR and PRICE86.

Table 32 shows the results for the F1 and F2 models. Based on the F-test, we cannot reject the joint hypothesis with any reasonable level of confidence that all the coefficients in model F1 are not significantly different from zero. This suggests that Friedman's model is too simplistic; temperature choices may be rational, but they are not captured by his model. The F2 model takes the marginal cost basis of the Friedman model and adds marginal benefits that he assumes are either zero or invariant across consumers. The results from F2 are more encouraging, we can reject the joint hypothesis that all coefficients are zero. However, the negative sign on INS_1 and the insignificance of EFF1 and HLR are inconsistent with Friedman's theory.[9] In part, the results on EAST reflect relatively higher costs of fuel in that region, but the coefficient is barely significant.

We do find that temperature settings are systematically related to the type of dwelling, the presence of someone 65 or older, and the west region. Since we have corrected for variation in insulation, heat loss

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[9]In fact, we tried a number of versions of the F2 model, but rejected the null hypothesis that the inclusion of other variables significantly altered the explanatory power. PRICE86 was dropped in F2 because it was multicollinear with the EAST indicator.

Table 32. Models to test the Friedman Hypothesis model

	F1		F2	
	Coefficient	T-stat	Coefficient	T-stat
Constant	71.78	28.49	69.23	34.66
INS_1	-1.18	1.93	-1.61	2.68
EFF1	0.02	.69	0.01	.51
HLR	-0.002	2.01	-0.001	1.36
Price86	-0.47	1.63	-	-
East	-	-	-1.13	1.82
West	-	-	-1.53	2.20
South	-	-	-0.29	.46
DWL_1	-	-	-4.15	2.34
ELD_P	-	-	1.35	2.31
AG1_0	-	-	1.11	1.74
R^2	.024		.099	
ADJ R^2	.012		.075	
K	4		9	
N	332		332	
Std. Error	4.05		3.92	
F-test statistic	1.97		3.97	
Significance of F-test	0.098		0.00009	

rates, prices, and efficiency choices, we believe the result for WEST indicate attitudinal differences between the west and central regions. Alternatively, the result may indicate regional preferences for indoor temperatures, an assumption contrary to Friedman's hypothesis.

5.4. SUMMARY

This section explores the rationality of consumer choices regarding efficiency ratings and the implications of those choices for the related choice of indoor temperature settings. We find that many of the respondent choices are consistent with our economic-man model. Furthermore, all but one of the non-matching observations can be rationalized by very compelling information about the respondent.

The economic-man model is based on naive assumptions and the objective to minimize discounted heating costs, not unlike many of the models used to predict consumer choices. However, we use certain pieces of information in the model that are respondent-specific such as heating needs and the discount rates. Thus, we are careful to model economic man from a respondent's perspective, and not a social or average perspective.

Although the analysis involves many simplifications, we believe that the results support the argument that consumers are largely rational in their choice of efficiency ratings, given their set of heating needs, discount rates, and sizing assumptions. However, the simple economic man model can only explain the choices of less than half of the analyzed respondents without additional respondent-specific information. We point out that our economic-man model is not unlike many models used in diffusion analysis to predict the penetration rates of high-efficiency furnaces.

The analysis of the second rationality question, that of temperature settings, produces little support for the Friedman hypothesis. We find insufficient evidence that insulation investments and furnace efficiency levels are positively related to indoor temperature settings. However, we do find that other, respondent-specific factors are related to temperature settings such as age, type of dwelling, and regional attitudes or preferences. These factors reflect the marginal benefits of changes in temperature settings, an issue completely ignored by the Friedman model and many other models of energy use.

6. CONCLUSIONS AND RECOMMENDATIONS

This paper discusses an analysis of a national survey of recent gas-furnace purchases. We have examined the survey on the basis of the total sample and several sub-samples to address particular questions about the factors that affect the purchase and, in particular, the selection of energy-efficiency ratings. To conclude the paper, we return to the issues raised in Sections 1 and 2.

6.1. IMPLICATIONS FOR FUTURE STUDIES OF CONSERVATION INVESTMENTS

In the first section, we raise a general problem of selecting the appropriate theoretical framework to study conservation investments. The results of our study demonstrate that there is a need for an integrated framework that reflects economic man, attitudinal factors, and bounded rationality. However, there are specific aspects of each framework that we feel are more or less important.

The economic-man model works fairly well for about half of the sub-sample analyzed. However, to explain all the observations, it is necessary to augment the simple model with respondent-specific information on costs, gas-price and resale expectations, and attitudes about conservation.

Numerous results support the argument that attitudes are important in the selection of high-efficiency furnaces. However, we also find that distinguishing attitudes on the basis of preferred selection criteria is not very helpful. For example, although saving energy is identified as an important criterion, it is not a guarantee of selecting a high-efficiency furnace. We believe that this criterion represents a commonly used sales slogan that consumers associate with their purchase, regardless of the actual energy-efficiency rating. The criterion that does demonstrate a positive influence on efficiency choice is the energy-efficiency rating reason. Furthermore, when this reason is coupled with other supporting reasons like saving energy and inexpensive fuel costs, we find respondents' choices are more likely to reflect true conservation behavior.

We cannot reject the bounded rationality arguments on the basis of our results. Although for the sub-sample analyzed with the economic-man model we find consumer choices are easily rationalized, we demonstrate a bias in our sub-samples according to awareness of the furnace attributes. What we cannot answer is whether or not this lack of awareness is related to bounded rationality or simple indifference to the survey. When we test for the affect of the bias in the efficiency-choice equation we find that it largely affects some unobserved variable rather than the ones we identify as significant in the equation. This unobserved variable may in fact be "degree of boundedness."

6.2. IMPLICATIONS FOR VIEWPOINTS ON THE GAS-FURNACE PROBLEM AND POLICY OPTIONS

We designed the survey and organized the results to address five alternative viewpoints on the gas-furnace problem. We now consider the implications for these viewpoints and what policy actions are more appropriate in light of our results.

1. The Information View: We find that for most of the respondents, the energy-efficiency rating is a poorly understood attribute of the furnace. For the more aware respondents, knowledge about this feature is much better than the general sample and aware respondents demonstrate a fairly

accurate recall of the information. Furthermore, these respondents seem to perceive correctly the efficiency-cost tradeoff among furnaces. There may be some credibility problem present in the acceptance of the information, as nearly 43% of the total sample did not know if the energy-efficiency rating accurately reflected the energy use of the furnace. Finally, the results indicate that information obtained by the shopping effort is causing the opposite of the desired effect with respect to selecting high-efficiency furnaces, and the problem is exacerbated by shopping more intensely.

Further policy efforts to promote information need to reflect the shopping paradox and the finding that consumers feel satisfied with the range of efficiencies offered to them by the dealers. More information in the market will be useful only if consumers are inclined to use it. We recommend that additional research be conducted to look at the role of the dealer in the provision of information to understand our results on shopping.

2. The Marketing View: We find a number of respondent characteristics that may be useful to marketing solutions. However, our study did not reveal any startling new results with respect to respondent characteristics. High income, high education, the presence of someone 65 and older, attitudes about resale, and positive conservation attitudes are positively correlated with higher efficiency choices. Examination of the non-efficiency criteria, which we hoped would help to develop new targeting strategies, reveals very little systematic behavior with respect to socio-economic characteristics.

For our sample, some socio-economic factors were not that important, e.g., presence of someone under 6 and household size. This is consistent with the mean age of the sample (50 years old). The results from the efficiency-choice equation suggest that younger home owners are less likely to purchase high-efficiency furnaces, thus, this may be an important target group for marketing strategies. Additionally, the southern region consistently demonstrated lower efficiency choices, which may be improved through marketing strategies to alter attitudes about conservation.

3. The Capital-Cost Barrier View: We find very little evidence to support the traditional policy actions associated with this view. Elicited discount rates were in the 6 to 15% range for the majority of the sample and time horizons were 10 to 20 years for a third of the respondents. These values are not unusual given the uncertain nature of the purchase. Furthermore, 50% of the sample perceived a positive relationship between resale value and high-efficiency furnaces, and for 43% of those who did, the expected resale value exceeded the cost differential. Finally, we found almost no evidence that ability to finance or the availability of credit has an influence on the selected furnace. While low-cost loans are a commonly suggested solution to alter high discount rates or short time horizons, they are not likely to be effective for this problem. Rebate programs targeted to high-efficiency furnaces may prove a better solution, but if consumers do not perceive a cost barrier they probably will not seek out such programs.

4. The Irrationality/Rationality View: As already discussed, the only indication that bounded rationality may be an acute problem in the furnace decision emerges from the analysis of an awareness bias. We can reject the crisis argument on the basis that the majority of the sample purchased a new furnace while their old one was still operating. However, for about 25% of the sample, the old furnace had stopped working, and for these respondents, we find that the in-stock criterion is positively associated with this type of purchase while the energy-efficiency rating criterion is negatively associated. Thus, we may question to what extent high-efficiency furnaces are kept in stock by dealers for the crisis buyers.

Our hypothetical problems indicate that rationality is just as likely as irrationality in switching behavior among preferred furnace options. However, our economic-man analysis suggests that in actual purchases, the respondents are more rational than expected from the hypothetical-choice results. This finding supports the criticisms of hypothetical-choice problems, where the interest of the respondent is often taken for granted. Our analysis of the Friedman hypothesis provides another cautionary note to attempts to model rational behavior. The factors that the economist may regard as important rationality factors (usually based on an income metric) and those considered by consumers may not coincide.

Lastly, we identify one aspect of the furnace decision that has been largely ignored by other studies. This is the relationship between size and furnace cost. Our results indicate that oversizing may be a pervasive problem in the market. We do not believe this result is due to irrationality on the part of consumers, since sizing is a calculation that is likely to be done by the dealer within the constraints of available furnace sizes.

If oversizing is a common error, then there are two cost implications for energy conservation efforts. First, bigger furnaces cost more than smaller ones; therefore, they compete directly with the efficiency attribute for consumer expenditures. Second, an oversized furnace will not cycle efficiently and thus will reduce the designed energy-efficiency of the unit. The consumer will pay more for fuel with an improperly sized furnace as well as overspend on the capital cost. To explore the extent of the sizing problem, we recommend additional research using home-audit data and information from dealers on the sizing process. If units are systematically oversized, policy actions on the dealer-side of the market may act to increase energy efficiency by simply reducing competing expenditures on unnecessary size increments.

Our analysis has satisfactorily answered some questions about conservation investment in high-efficiency furnaces, but it has also raised a number of additional questions. Issues we believe are worth pursuing include: why are consumers less likely to select high-efficiency furnaces when they undertake a greater shopping effort; why furnaces are systematically oversized; whether or not high-efficiency furnaces are routinely kept in stock for crisis purchases; and what type of information sellers pass along to consumers regarding high-efficiency furnaces. A true understanding of the problem and the appropriate policy actions requires additional information on the seller-side of the market.

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APPENDIX A

Appendix A

MANUFACTURERS OF GAS FURNACES

Company Name/Divisions	City/State
Ace Beuhler Inc.	Reading, PA
Addison Products/Dearborn Stove	Addison, MI
Air Dynamics	South El Monte, CA
Ajax Boiler and Hester Co.	Gardena, CA
Aldrich Co.	Wyoming, IL
Argo Industries	Berlin, CT
Arkla Industries	Evansville, IN
Atlantic Heating and Cooling	Baltimore, MD
Axeman Anderson Co.	Williamsport, PA
Bard Mfg. Co.	Bryan, OH
Blueray Systems Inc.	Schuykill Haven, PA
Borg Warner Corp./York	York, PA
Boston Stove Co.	Reading, MA
Brad, McClung and Pace	Portland, OR
Steam Corp	Pern, IN
Burnham Corp.	Irvington, NY
Carrier Corp./BDP	Syracuse, NY
Coleman Co.	Wichita, KA
Columbia Boiler Co.	Pottstown, PA
Consolidated Industries Corp.	Lafayette, IN
Cornelius Engineering Co.	Tigard, OH
Crown Industries Inc.	Philadelphia, PA

MANUFACTURERS OF GAS FURNACES (Cont'd)

Company Name/Divisions	City/State
Dornback Furnace	Eastlake, OH
Dover Corp.	Louisville, KY
Ducane Heat Corp.	Blackville, SC
Dunkirk Radiator Corp.	Dunkirk, NY
Eastern Foundry Co.	Boyertown, PA
Edwards Engineering Corp.	Pompton Plains, NJ
Empire Stove Co.	Belleville, IL
Fasco Industries Inc.	Rochester, NY
Fedders Corp./Air Temp	Edison, NY
Ford Products Corp./The Carlin Co.	Valley Cottage, NY
Fraser and Johnston Co.	San Lorenzo, CA
General Electric Co.	Louisville, KY
General Machine Corp./Electric Furnace Mfg.	Emanus, PA
Goodyear Tire and Rubber/Duo Therm	LaGrange, IN
Heat Controller Inc.	Jackson, MS
Hydrotherm Inc.	Northvale, NJ
Intertherm Inc.	St. Louis, MO
ITT Nesbitt	Philadelphia, PA
Johnson Corp.	Columbus, OH
King Electric Mfg. Co.	Seattle, WA
Lear Siegler Inc.	Holland, MI
Lennox Industries Inc.	Dallas, TX
Magic Chef/Armstrong Furnace, Gaffers and Sattler Inc.	Columbus, OH

MANUFACTURERS OF GAS FURNACES (Cont'd)

Company Name/Divisions	City/State
McNeil Corp./Southwest Mfg.	Aurora, MO
Metzger Machine and Engineering Co.	Milwaukee, WI
Meyer Furnace Co.	Peoria, IL
New Yorker Steel Boiler Co.	Colmar, PA
NEGEA Energy Products Inc.	Worcester, MA
Oil King Boilers and Warm Air	Reading, PA
Oneida Heater Co., Inc.	Oneida, NY
Patterson Kelly Corp./Thermo-pak	Memphis, TN
Peerless Heater Co.	Boyertown, PA
Pennco Inc.	Clarendon, PA
Raytheon/Amana	Amana, IN
Raypack Inc.	Westlake Village, CA
Reed National Corp./Sterling Radiator	Westfield, MA
Reimers Electra Steam Corp.	Clearbrooke, VA
Repco Products Corp.	Philadelphia, PA
Rheem Manufacturing	Fort Smith, AR
Rite Engineering and Mfg. Corp.	Downey, CA
Singer Co.	Red Bud, IL
Smith Jones Inc./SJC Corp.	Elyria, OH
Slant/Fin Corp.	Greenvale, NY
A. O. Smith Corp.	Kankakee, IL
H. B. Smith Co.	Westfield, MA
Specialty Mfg. and Supply Corp./Dynatherm	Easton, PA

MANUFACTURERS OF GAS FURNACES (Cont'd)

Company Name/Divisions	City/State
Square D Co.	Mesquite, TX
Stomdale Industries Inc.	Lima, OH
Suburban Mfg. Co.	Dayton, TN
Teledyne Laars	N. Hollywood, CA
Thermo-Products Inc.	North Judson, IN
TPI Corp	Johnson City, TN
The Trane Co.	Clarksville, TN
Triad Sales Corp.	Lincolnwood, IL
Utica Radiator Corp.	Utica, NY
Van West Mfg. Co.	Peckville, PA
Victa-Hytemp	Depew, NY
Weather King Inc.	Orlando, FL
Weben Ind.	Dallas, TX
Westinghouse Electric/Luxaire	Elyria, OH
Whirlpool Corp./Heil Quaker	Nashville, TN
Williamson Co.	Cincinnati, OH
Wylain/Weil McLean, Friedrick	Michigan City, IN
XX Century Heating Ventilating Co.	Akron, OH
John Zink Co.	Tulsa, OK

Source: U.S. DOE (1982)

APPENDIX B

Appendix B

Methodology Report for a National Survey on Household Replacements of Gas Furnaces

Submitted to:

Martin Marietta Energy Systems, Inc.
Oak Ridge National Laboratory
P. O. Box 2008
Oak Ridge, TN 37831

Submitted by:

Market Facts, Inc.
1730 Pennsylvania Ave., NW
Washington, DC 20006

June 22, 1987

Methodology Report for a National Survey on Household Replacements of Gas Furnaces

This report presents the methodology used to conduct a survey, for Martin Marietta Energy Systems, of households who have recently purchased a replacement gas furnace. The principal object of the survey was to determine the decision criteria used in making such purchases. Topics covered in the report include:

- Sampling
- Questionnaire Development and Pretesting
- Survey Execution
- Limitations of the Data
- Data Processing and Tabulations

Sampling

Market Facts' Consumer Mail Panel was the sample frame used for the survey. The Mail Panel is a standing group of over 220,000 households throughout the United States that have been recruited to participate in telephone and mail research surveys. Panel members include all social, demographic and geographic segments of the population.

Sample selection for this research took place in three steps. First, a balanced national sample of 75,000 households was selected from the total membership of the Mail Panel. The sample was selected to proportionally match U.S. statistics on five variables:

- Geographic Region
- Population Density
- Household Income
- Age of Panel Member
- Household Size

Second, a screener was sent to all 75,000 households to identify those households qualifying for the next study (see end of this Appendix). The next step involved identifying the qualified households from the screener returns. To qualify, a household was required to have purchased a replacement gas furnace between March 1, 1986 and February 28, 1987. Of the 56,805 screener returns, 997 households qualified for the study.

Questionnaire Development and Pretesting

Martin Marietta had principal responsibility for development of the content of the questionnaire. Market Facts reviewed the draft instrument and made suggestions for revisions. All changes made by Market Facts were approved by Martin Marietta prior to pretesting the questionnaire.

The questionnaire was pretested with qualified respondents. To simulate actual survey conditions, the questionnaire was mailed to 25 respondents drawn from the list of qualified households. A cover letter was enclosed with the questionnaire. The cover letter explained the intent of the survey and the pretest, identified who in the household would be the qualified respondents, and requested comments about any questions not understood and/or improvements that could be made in the questionnaire (see Appendix for a copy of this letter). Twenty-two respondents returned completed questionnaires.

Results of the pretest were used to further revise the instrument; only minor changes were incorporated. A copy of the approved survey questionnaire is included at the end of this Appendix.

Survey Execution

All qualified households, with the exception of those participating in the pretest, were included in the survey sample for mail-out--972 households. Survey packets were mailed to sample households on April 27.

These packets included a cover letter similar to that used in the pretest, a questionnaire and a postage-paid return envelope.

Approximately ten days after the packets were mailed, a reminder postcard was sent to all survey households. Instructions were included to disregard the postcard if the questionnaire had already been completed and mailed back.

Altogether, respondents returned 639 complete and usable questionnaires--a 66% response rate--by the time the acceptance of returns was closed off on May 27. A sample of 639 is accurate at the 95% level of confidence within a maximum range of ± 3.9 percentage points. Thus, for percentages based on the entire sample falling at or around 50%, the "true," population figure will be between 46.1% and 53.9% 19 times out of 20. Sampling error for statistics farther away from 59% will have correspondingly narrower ranges. The reliability of estimates based on sample subgroups smaller than the total sample will be lower.

Limitations of the Data

Because the sample was drawn from a mail panel of households that have agreed to participate in research, it is not truly a probability sample in which every household has a known chance of being selected. One must keep this in mind when interpreting the data. The original balanced sample of 75,000 was carefully selected to match the U.S. population on the five variables listed previously. There was no *a priori* relationship between selection into the original balanced sample and purchase of a replacement gas furnace within the specified time period because selection of this sample took place prior to the identification of qualified households.

While there are no known biases associated with Market Facts' Consumer Mail Panel, the households differ from the general U.S. population and the total population in two ways. First, unlike the general population, all panel members are literate. Second, the households have agreed to participate in consumer research which may mean that they have higher levels of interest in consumer issues than do people who do not choose to participate in a panel. It is unclear how these differences may have impacted, if at all, the results of this survey.

Data Processing and Tabulations

Once the interviews were received, logged-in and checked, the forms were transferred to Market Facts' data processing department. First, the open-ended answers were coded by experienced coders. Next, information from the questionnaires were keypunched, keyverified, and edited to produce an accurate magnetic tape data file. Marginal tabulations of each questionnaire were produced. A copy of the data tape, spread codesheet and marginal tabulations were then provided to Martin Marietta Energy Systems.

SURVEY

Dear Panel Member,

Job No. 6799

Today, I have some questions about your home heating system. Please answer these questions, and return the post card at your earliest convenience. As always, thanks for your help.

Cordially,

1. Have you purchased a new furnace or other type of primary heating system to replace an existing furnace or other type of primary heating system in your home within the last 2 years?

   Yes 1   No ...... 2 ---> (STOP AND RETURN CARD)

   (9)

2. When did you purchase this new heating system?

   Between September 1, 1986 and February 28, 1987 1
   Between March 1, 1986 and August 31, 1986 2
   Between March 1, 1985 and February 28, 1986 3

   (10)

3. What type of replacement heating system did you purchase?

   Gas furnace 1
   Electric (non-heat pump) 2
   Electric (heat pump) ... 3
   Oil furnace 4
   (11)
   Other system (PLEASE SPECIFY:)
   ____
   ____

Dear Panel Member:

Soon we will be conducting a study to learn about how people purchase a gas furnace as a replacement for an existing furnace or other type of primary heating system. As we will be trying to get the best information possible, your household is among a select few we have chosen to help us design the questionnaire for the study.

In a recent mailing, you indicated that your household purchased a replacement gas furnace within the past year. Specifically, we are interested in the factors that were important in the selection of the particular gas furnace you purchased rather than some other gas furnace. Our primary interest is to learn what was important to you when you made your purchase.

We would like to have the person in your household who is most knowledgeable about your recent furnace purchase decision look at the questionnaire. Please answer the questions as best as possible, and write down in the margins comments about any questions that are not clear or are not understood. Please return the questionnaire in the postage-paid envelope we have provided within five days.

Thanks for your valuable help!

Sincerely,

Marie

Dear Panel Member:

We are conducting a survey to learn about how people purchase a gas furnace as a replacement for an existing furnace or other type of primary heating system. In a recent mailing, you indicated that your household has purchased a replacement gas furnace within the past year.

Specifically, we are interested in the factors that were important in the selection of the particular gas furnace you purchased rather than some other gas furnace. Our primary interest is to learn what was important to you when you compared different gas furnaces before making your purchase.

The person in your household who is most knowledgeable about this purchase decision should complete this survey. Please answer the questions as best as possible, and return the questionnaire in the postage-paid envelope we have provided within five days.

As always, thanks for your help!

Sincerely,

Marie

APPENDIX C

Appendix C

MARKET FACTS INC., 676 ST. CLAIR, CHICAGO, ILL. 60611 JOB NO.

JUN 5, 1987 10:32 AM CARD 01 6799-02

QU. BASE S/M COL. CODE DESCRIPTION PAGE 0003

CODING: THE FOLLOWING IS THE LIST OF GAS FURNACE COMPANIES, IN THE FORMAT: COMPANY:TRADE NAME

CODE	DESCRIPTION		
	CODING: THE FOLLOWING IS THE LIST OF GAS FURNACE COMPANIES, IN THE	00250	•
	FORMAT: COMPANY:TRADE NAME	00260	•
001	ADDISON PRODUCTS CO:	00270	•
	WEATHERKING	00280	•
020	AIRCO PRODUCTS	00290	•
040	AMANA REFRIGERATION	00300	•
050	ARCOAIRE-SNYDER:	00310	•
	GENERAL CORPORATION	00320	•
051	ARKLA	00330	•
060	BDP COMPANY	00340	•
061	BARD MANUFACTURING CO.	00350	•
070	BECKETT	00360	•
080	BORG-WARNER	00370	•
100	BRYANT	00380	•
110	BURNHAM	00390	•
120	CARRIER A/C	00400	•
130	CENTRAL ENVIRONMENTAL	00410	•
	SYSTEMS:YORK	00420	•
131	CENTENIAL II	00430	•
140	CIRCLE COMBUSTION CORP	00440	•
150	CLARE BROTHERS	00450	•
151	CLARK	00460	•
160	COLEMAN COMPANY	00470	•
161	COMFORTMAKER, SNYDERGEN	00480	•
	CORP/GENERAL CORP	00490	•
162	CONSOLIDATED INDSTRIES	00500	•
	CORP:PREMIER	00510	•
163	COLUMBIA	00520	•
164	COZY	00530	•
165	COOK	00540	•
166	CORONADO	00550	•
167	COMFORT MASTER	00560	•
180	DAY & NIGHT	00570	•
181	DAYTON ELECTRIC MFG CO	00580	•
200	DORNBECK	00590	•
230	DUOMATIC/OLSEN INC:	00600	•
	ULTRAMAX	00610	•
231	DUNKIRK	00620	•
240	EMPIRE	00630	•
241	EMCO	00640	•
242	ELECTRO-AIR	00650	•
270	FEDDERS	00660	•
271	FRANKLIN	00670	•
300	GLOWCORE CORP	00680	•
301	GENERAL ELECTRIC	00690	•
310	GALAXY	00700	•
330	GOODMAN MFG CO:	00710	•
	JANITROL, GMC, JOHNSTONE	00720	•

Index:
Gas furnace companies.

CONTINUED

CODE	DESCRIPTION	
350	HEAT CONTOLLER INC:	00730
	CENTURY,CONFORTAIRE,	00740
	RECLAIMER	00750
351	HEIL-QUAKER CORP	00760
352	HEAT MAKER	00770
360	HI BOY	00780
380	HORIZONTAL	00790
381	HONEYWELL	00800
382	HOLLY	00810
385	HOT POINT	00820
390	HYDROTHERM	00830
400	INTERTHERM, INC	00840
401	INTERNATIONAL	00850
402	INSTALLATION	00860
430	J.V.C.	00870
431	JOHN ZINK	00880
432	JORSAIRE	00890
480	LENNOX	00900
485	LOUISVILLE TIN & STOVE	00910
490	LAU VENT	00920
491	L.S.C.	00930
492	LUXAIRE	00940
500	MAGIC CHEF	00950
501	MARSH	00960
510	MCQUAY, SNYDERGENERAL	00970
	CORP	00980
520	METZGER MACH & ENGRING	00990
	CO:MILWAUKEE THERMOFLO	01000
530	MILLER	01010
590	ONEIDA HEATER CO:	01020
	ONEIDA ROYAL	01030
610	PAYNE	01040
611	PERFECTION	01050
612	PEERLESS	01060
620	PREMIER FURNACE CO:	01070
	PREMIER, SUNBURST,	01080
	SUNGLOW, P.F.C.	01090
621	PREWAY INDUSTRIES	01100
670	RHEEM	01110
700	RUUD MANUFACTURING	01120
710	SEARS, ROEBUCK, & CO:	01130
	KENMORE	01140
711	SINGER	01150
720	SENTINEL	01160
740	SMITH, H.B.	01170
741	SLANT FIN	01180
750	SQUARE D. CO	01190
760	SUNBELT	01200
761	SUBURBAN	01210

CONTINUED

762	SUPERFLAME	01220	•
770	THERMO PRODUCTS, INC:	01230	•
	THERMO PRIDE	01240	•
771	TELEDYNE LAARS	01250	•
800	TRANE CO:TRANE,XL80,	01260	•
	XL90	01270	•
830	UTICA	01280	•
840	UNITRAL-MOR-FLO	01290	•
850	VAILLANT	01300	•
870	WARM MORNING	01310	•
880	WEIL-MCLAIN	01320	•
890	WILLIAMSON COMPANY	01330	•

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