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CONSUMER PURCHASES OF ENERGY-EFFICIENT REFRIGERATORS AND IMPLIED DISCOUNT RATES

Alan Meier and Jack Whittier

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Alan Meier and Jack Whittier*

Buildings Energy Data Program
Lawrence Berkeley Laboratory
University of California
Berkeley CA 94720

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*The Energy Institute, New Mexico State University, Las Cruces, NM 88003.

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Alan Meier

Energy and Environment Division,
Lawrence Berkeley Laboratory,
University of California,
Berkeley, CA 94720 USA

Jack Whittier

The Energy Institute,
New Mexico State University,
Las Cruces, NM 88003 USA

ABSTRACT

Consumer purchasing patterns of a standard and an energy-efficient refrigerator are presented. These models differed only in their initial cost and electricity consumption. Consumers in regions with higher electricity prices tended to buy the more efficient model. A distribution of implied consumer discount rates is constructed. Roughly 2/5 of the consumers behaved as if they had real discount rates above 60%, 1/5 between 35% and 60%, and 2/5 less than 35%. Some of the distribution in apparent discount rates may be attributable to market failures.

1. INTRODUCTION

To what extent are consumers willing to offset future energy costs with an investment today? Knowledge of consumer discount rates as applied to energy conservation investments is essential for predicting responses to higher energy prices and the demand for energy-efficient appliances and equipment.

There have been limited attempts to estimate consumer discount rates as applied to energy conservation investments. These analyses required extensive information pertaining to the consumer's decision, including a conservation measure's cost, energy savings, and consumer purchasing patterns. Average values or estimates were often substituted because detailed data for individual consumers are rarely available. Corum and O'Neal, for example, relied on computer simulations of prototype houses to estimate the energy savings from insulation.[1] Johnson relied on utility bills as a proxy for energy efficiency and compared them to the sale prices of houses.[2] Hausman's study relied on regression techniques to estimate electricity savings from improved air conditioner efficiencies.[3] The range in reported consumer discount rates is large, from negative rates found by Johnson to over 25% by Hausman. In another study, Gately discussed the apparent high discount rates implied by the sale of standard and high-efficiency refrigerators.[4]

Consumers evidently purchased the standard refrigerators even though a small additional investment would enable them to buy a high-efficiency model. The simple existence of the standard model (and the assumption that people bought it) implied some consumers behaved as if they had discount rates above 300%. We report below consumer purchasing patterns for one model of energy-efficient refrigerators. We have calculated implied discount rates for these investments and offer some explanations for the high observed discount rates.

2. THE DATA

A large national retailer sold two models of refrigerators between 1977 and 1979.* The two models were virtually identical: they were both frostfree, had similar features and about 17 cubic feet of refrigerated volume.** However, the two models differed with respect to electricity consumption and initial price: the high-efficiency model cost about $60 more than the standard, but used 410 kWh/yr less electricity. This differential in list prices remained constant throughout the three years (even when the models were offered at discounts), but sales personnel were permitted to bargain, so the actual price differential was smaller. A nationwide price survey indicated that the actual difference in price was $40 (the value used in this study). Table 1 lists the sales of standard models sold in each sales region expressed as a fraction of the combined sales of the two models. (Combined annual sales for the two models were several

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* The company has requested anonymity since this is proprietary sales information.

** The frostfree, top-door freezer is the most popular class sold in the United States; roughly 50% of 1980 total refrigerator sales are in this category, with most of these in the 17-20 cubic foot category. (Source: American Home Appliance Manufacturers Industry data.)

Table 1. Sales patterns for the matched pair of standard and high-efficiency refrigerators. Average regional electricity prices (below) were calculated using electricity sales and revenues data for each state. These prices conceal considerable variation. For example, average prices in California and Washington (both in the Pacific Region) were 4.2 cents/kWh and 1.5 cents/kWh, respectively.

Percentage of Matched-Pair Sales that were Standard Model[1]
(Standard / Matched-Pair)

Year	Midwest	East	South	Southwest	Pacific
1977	46%	37%	54%	73%	67%
1978	46%	35%	69%	67%	57%
1979	45%	40%	59%	76%	60%

Sales of High-Efficiency Refrigerators Expressed as a Percentage of Sales of All Models of this Brand[1]

Year	Midwest	East	South	Southwest	Pacific
1977	29%	42%	13%	6%	10%
1978	27%	42%	8%	7%	16%
1979	26%	46%	9%	4%	15%

1979 Average Residential Electricity Prices[2]
(in Cents/kWh)

Year	Midwest	East	South	Southwest	Pacific
1979	5.5	5.6	4.0	4.1	3.4

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[1] Personal communication from the manufacturer.

[2] Based on Edison Electric Institute, Statistical Yearbook of the Electric Utility Industry / 1979, Edison Electric Institute, Washington, D.C. 1980.

thousand in every region). Table 1 also shows the high-efficiency model's approximate contribution to the total sales of refrigerators. Since at least ten other models were sold at the same store, Table 1 indicates that the matched pair was clearly one of the most popular. Average 1979 electricity prices for five regions are also shown in Table 1.

The high-efficiency refrigerator was given significant advertising, both at point of sale and through the media. Sales personnel were instructed in the prominent features of the high-efficiency and many of them could tell customers of the anticipated dollar savings. In addition, a prominent consumer magazine selected the high-efficiency model as a "best buy" and listed the dollar value of the monthly electricity savings for two electricity rates.

3. ANALYSIS

Consumers in regions with high electricity rates bought a higher proportion of the efficient model. The East Region, where the average electricity price was 5.5 cents/kWh, reported the highest sales fraction of the efficient model. In the Southwest and Pacific regions, where electricity prices were almost half that of the East, sales of the high-efficiency model accounted for only 24-43% of the matched pair sales. Neither model was popular in the Southwest, possibly because consumers in this warm region preferred larger models. For this reason we have excluded the Southwest region from the analysis.

The economically rational consumer will be indifferent between the standard and high-efficiency model if the present value (using the consumer's discount rate) of the electricity savings equals the additional cost of the high-efficiency model. If the standard model is preferred, then his discount rate must be higher than that when he is assumed to be indifferent. We use this observation to calculate minimum implied discount rates for consumers.

The condition for indifference between the two models occurs when the incremental cost equals the present value of the electricity savings,

$$I = P_o E \int_0^n e^{(f-r)} dt \qquad \text{(Eqn.1)}$$

where,

I = incremental investment ($)
P_o = initial electricity price ($/kWh)
E = annual electricity savings (kWh/year)
r = real discount rate (per year)
f = real electricity price escalation rate (per year)
n = amortization period (years)

Integration and rearrangement of Eqn. 1 yields,

$$\frac{I(f-r)}{P_o E} - e^{(f-r)} + 1 = 0 \qquad \text{(Eqn.2)}$$

We can solve Eqn. 2 for r because we have values for the other variables, that is, the incremental price, electricity savings, electricity prices, and their future rate of increase. If electricity costs 5.5 cents/kWh (the 1979 average in the Midwest Region), then a consumer must have had a real discount rate above 56% if he selected a standard model over the high-efficiency. Of course, this assumes that consumers had sufficient information to compare the costs and benefits. We contend that consumers had access to unusually good information, and certainly better than that found for most other energy conservation investments.*

Table 2 lists real discount rates for a range of electricity prices from 2 - 10 cents/kWh. Since we do not know the consumer's amortization time for refrigerators, we calculated the discount rates for 5, 10 and 20 years. (The typical physical lifetime of a refrigerator is 20 years.)[5] The implied discount rate is insensitive to length of amortization period even at moderate electricity prices, so this uncertainty is not especially damaging. An energy price escalation adjustment must be included if the consumers are thought to have considered the rising electricity price in their cost-benefit calculation. (The adjustment is explained in the legend for Table 2.)

DISCUSSION

The sales data in Table 1, combined with the calculated discount rates in Table 2, suggest that a large proportion of consumers behave with high real discount rates. In the East, for example, 40% of the refrigerator buyers in 1979 appeared to have discount rates above 58% (because they bought the standard model). In the Pacific Region, 60% of the consumers appeared to have discount rates above 34%.

* Unlike heating or cooling, the consumer has little control over the electricity consumption of a refrigerator.

Table 2. Implied discount rates with different assumptions for electricity prices and amortization periods. A consumer will be indifferent between the purchase of the high efficiency and standard refrigerators at the specified electricity price and amortization period. All of the above calculations assume that the incremental cost of the high-efficiency refrigerator was $40, the incremental energy savings was 410 kWh/year, and there was no (real) electricity price escalation. The discount rates listed in the table must be increased if a consumer is to remain indifferent in the face of anticipated electricity price inflation. In the Pacific Region, for example, a consumer with a 34% discount rate will be indifferent between the two models (assuming a 10-year amortization) if electricity prices do not increase. However, to remain indifferent if electricity prices are expected to increase at a 15% nominal rate, then the consumer must use a 49% discount rate.

Implied Real Discount Rates for Selected Electricity Prices and Amortization Times

	Amortization Time			
Initial Price	5 Years	10 Years	20 Years	Location
2 cents/kWh	1%	17%	21%	
3 cents/kWh	19%	29%	31%	
3.4 cents/kWh	26%	34%	35%	Pacific
4 cents/kWh	34%	41%	42%	South
5 cents/kWh	46%	51%	52%	
5.5 cents/kWh	53%	56%	56%	Midwest
5.6 cents/kWh	54%	58%	58%	East
6 cents/kWh	58%	62%	62%	
8 cents/kWh	80%	82%	82%	
10 cents/kWh	102%	102%	102%	

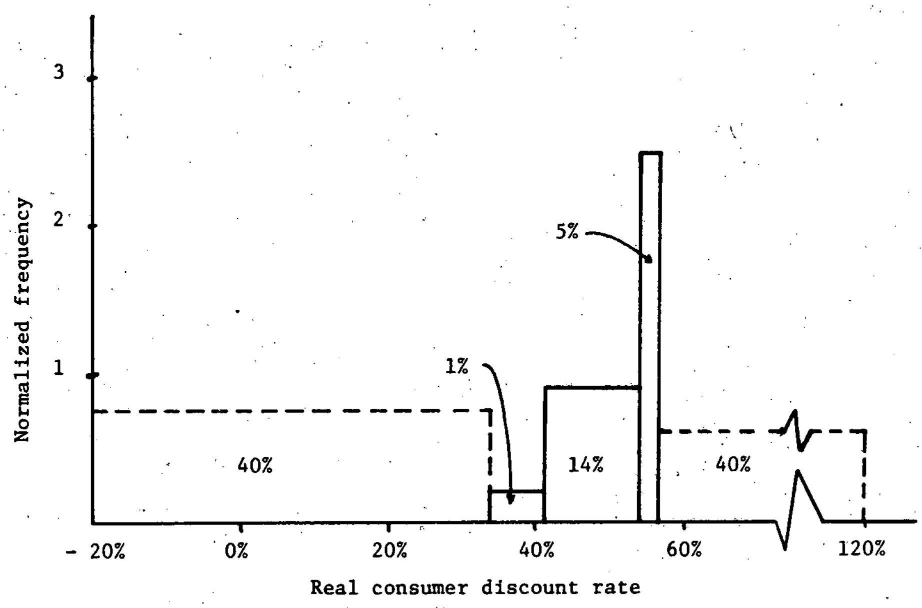

Figure 1. The distribution of consumer discount rates implied by consumer purchasing patterns of energy efficient refrigerators. The East Region data showed that 40% of the consumers had real discount rates above 58% and the Midwest Region showed that 45% of the consumers had discount rates above 56%. Therefore, 5% of the consumers had real discount rates between 56% and 58%. The remaining boxes to the left were constructed in a similar fashion. The dashed boxes at the two ends are based on the assumption of no discount rates less than -20% or above 120%. Equivalent nominal discount rates are about 15% higher than those shown in the Figure.

Our data can be used to construct a distribution of consumer discount rates. We know some variation in discount rates must be present because of the split in sales. Some consumers -- perhaps the wealthier ones -- will have lower discount rates while, others -- perhaps the poorer ones -- will have higher rates. (Hausman, for example, reported decreasing discount rates with increasing income.) We assumed that the distribution of consumer discount rates is the same for all sales regions. Put another way, there is a single distribution describing consumer discount rates in the United States which is identical to that of each sales region. (Such an assumption seems reasonable; we know of no studies indicating geographical differences in consumer discount rates.)

Figure 1 is the distribution of discount rates indicated by our data. We assumed that all consumers had discount rates below 120% and above -20% in order to provide closure. Clearly the data are too scanty to construct a smooth distribution. Nevertheless, Figure 1 suggests that considerable variation in discount rates exists: about two fifths of the consumers have real discount rates below 35%, one fifth between 35% and 60%, and another two fifths greater than 60%. The equivalent nominal rates would be about 15% higher.

There is an implicit story behind this analysis. The consumer has already chosen both the class of refrigerator and the store in which he will buy it. Upon entering the store, he is confronted with the final decision, namely whether to buy the standard or high-efficiency model. For some consumers, this may be realistic. The models are in the most popular size and class, and the manufacturer is a respected source of appliances. But there are several reasonable purchasing scenarios where the consumer never compares the standard to the efficient model. For example, the consumer may have compared high-efficiency refrigerators offered by other manufacturers, and found this one to be superior (or inferior). Store managers reported a significant increase in sales of the high-efficiency model after publication of the consumer magazine's recommendation, which supports the latter selection process. (Such behavior would distort the matched-pair analysis performed here by implying a greater preference for the high-efficiency model.)

A consumer especially sensitive to energy prices might switch to an entirely different class of refrigerator. The "partial defrost" refrigerators consume several hundred kilowatt-hours per year less than the frost-free models.[6] Sales data for all refrigerators (by class and manufacturer) would be needed to account for alternative purchasing decisions. Nevertheless, it is significant that such a large proportion of consumers avoided an energy conservation investment having little risk and paying back in less than 5 years.

We suspect that market failures, rather than high discount rates, in part account for the continued purchase of the standard models. Even though we believe that the customer was provided with unusually good information to make a realistic cost-benefit decision, no doubt some persons did not receive it. The sales data reported here occurred before the introduction of the Federal Trade Commission's "Energyguide" appliance labels. Unfortunately the manufacturer discontinued production of the matched-pair in 1980, so we could not trace the labels' impact on purchasing patterns.

Appliances are also purchased by home builders and landlords. These buyers lack any incentive to invest in appliances with higher efficiencies because they do not pay for the appliances' subsequent electric consumption. Some refrigerator manufacturers sell half of their total production to home builders.[7] We estimate that as much as half of all refrigerators are purchased by builders and landlords who will not be paying for the appliances' electricity consumption. These buyers may be largely responsible for the purchases of standard models, while consumers who expect to pay the electric bills are buying the efficient model. The brand discussed here is not popular with builders, but may be with landlords. Again, we need much more detailed information before reaching definitive conclusions.

The high discount rates found in this study suggest that the response to higher electricity prices, as reflected in the purchase of higher efficiency equipment, will be limited. A large proportion of consumers will simply not invest in energy conservation unless the payback is extremely short (less than two years). In contrast, electric utilities typically use 10 - 15% real discount rates when planning new energy supply facilities. This asymmetry in investment behavior leads to distortions in the balance between energy demand and supply, and provides an argument for mandatory appliance energy efficiency standards.

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TECHNICAL INFORMATION DEPARTMENT
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720