Joint Center for Housing Studies
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June 2006
N06-2

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Abstract

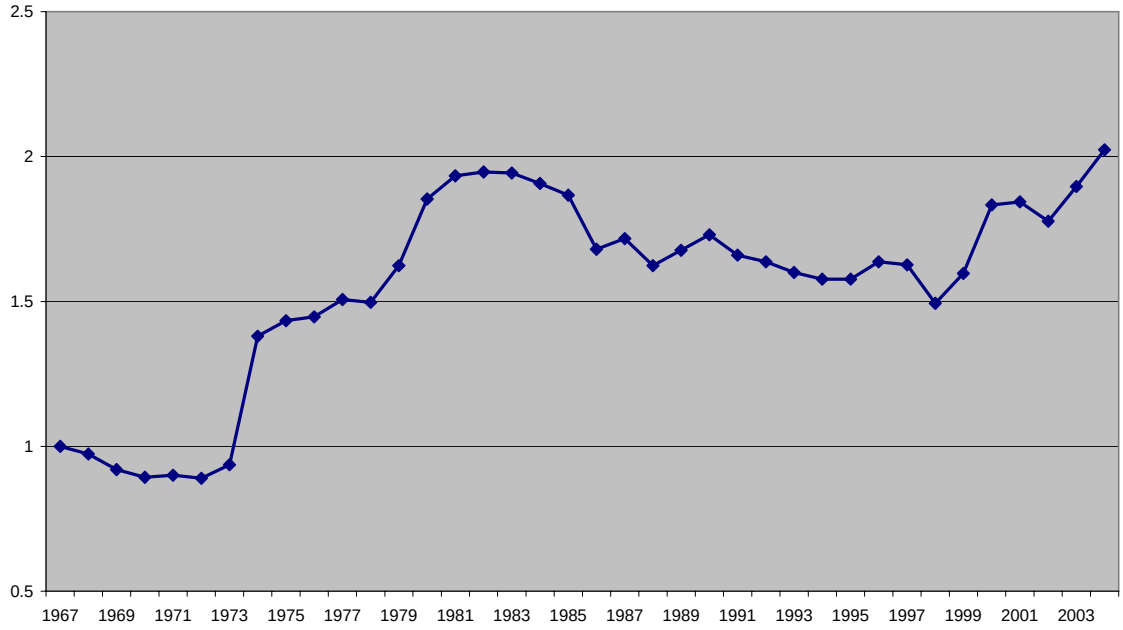
Current increases in the cost of home energy have placed focus on consumer behavior relative to home energy efficiency. For as much attention as the topic receives, its analysis, however, is widely lacking. This paper examines home energy costs and energy related remodeling activity, addressing the question of whether or not rising home energy costs lead to increased investments in energy efficient retrofits. This paper looks at the pattern of home energy costs since the 1970s, short and long term household responses to shocks in the cost of home energy, demographic characteristics and the probability of investments in efficiency, and finally, the actual levels of expenditures on energy efficient retrofits in recent years. The results suggest that the cost of home energy has only a limited impact on energy efficient retrofits, and that these efficiency investments tend to occur years after price increases in home energy.

Introduction

In light of the recent increases in home energy costs, it is important to analyze how households generally react to rising energy prices to better understand future demand patterns. The purpose of this analysis is to address the question of whether rising home energy costs lead homeowners to invest in energy efficient retrofits. Furthermore, if so, how long will it take before the investments are undertaken? To answer these questions, trends in home energy costs since the mid 1970s, directly after the OPEC oil embargo, were analyzed. The significant home energy price increase from this oil price shock allowed analysis of how households responded in both the short and long term during this period. Were they more likely to make immediate investments in conservation to increase the efficiency of their home, or were they more apt to make changes in their lifestyles to offset rising home energy costs? Additionally, looking at household demographics demonstrates how responses vary by household income, age of the householder, and level of home energy use. Finally, using recent experience for which more detailed data on home improvement expenditures is available permits the assessment of how energy related improvements relates to the level of home energy costs, and how long it takes before household responses are implemented. Through the analyses performed, we may conclude that home energy costs have a limited impact on energy sensitive retrofits, and in the small percentage of cases where home energy cost increases do encourage increased investments in energy efficiency, it normally takes several years for those investments to be implemented.

Exhibit 1. Home Energy Costs at an All-Time High

Index: 1967 = 1.0; adjusted for inflation.



Source: Energy cost index is based on residential electricity, residential natural gas, imported oil and exported oil annual price data from the Energy Information Administration, indexed to year 1967=1.0.

Home energy costs, displayed in Exhibit 1, have been rising since 1967. They reached an all time high in 2004, even after adjusted for inflation, surpassing the high levels witnessed in the early 1980s. The energy cost index presented was calculated using the Energy Information Administration's annual energy price data series for residential natural gas, residential electricity, and an average of imported and domestic oil. Each price series was indexed to year 1967, then aggregated and divided by three, for the three price series, to get the total home energy cost index (see Exhibit 1).

Responses After the 1973-1974 OPEC Oil Embargo

A few periods stand out as having dramatic increases in home energy costs. From 1973 to 1974 home energy costs rose by 47 percent, by far the most drastic increase in the time period studied (1967-2004). Therefore, studying household reactions to this cost increase allows us a reasonable best case scenario for capturing household reactions. It presents an extreme situation; surely if changes in home energy costs encouraged households to make investments in energy related retrofits, those actions would be visible following a 47 percent home energy cost increase. Using survey data and literature from this period, it becomes clear that most

households initially respond to rising home energy costs by making only minor lifestyle adjustments that produce quick results and require no investment.

Exhibit 2 shows the results of a study done shortly after the 1973-1974 oil shock. It is clear that the majority of households responded by making minor changes requiring no investment. Between the combination of the two groups of energy saving activities—lifestyle changes and conservation investments—the surveyed households managed to reduce energy consumption by 12 percent in the year directly following the oil price shock.

Exhibit 2. Surveyed Household Responses to 1973 Home Energy Cost Increase

LIFESTYLE CHANGES	INVESTEMENTS IN EFFICIENCY
49% Turned down thermostat	17% Added weatherstripping
66% Used air conditioner less	13% Installed storm doors or windows
75% Used less electricity	10% Insulated floors / walls / or ceilings

Source: Frieden and Baker, 1983.

As shown above, 49 percent of responding households turned down their thermostat in the winter to save on home energy consumption, and 66 percent of households with air conditioners reportedly used their air conditioners less during the summer. Most families also cut back on the use of their appliances, and three out of four households used less electricity, highlighting its cost as the reason for their reduction.

While the majority of households did react by decreasing their home energy consumption, few households reacted by making efficiency investments. Indeed only 17 percent of surveyed households added weatherstripping, with a reported median cost of less than $100. More costly at $300-$400, 13 percent of responding households installed storm doors or storm windows, and 10 percent of respondents insulated their floors, walls, or ceilings at a median cost between $100 and $200.

Although households reported only modest energy efficiency investments in the year following the home energy cost increase, it is possible that reactions were delayed by a few years after the cost increase. Therefore, examination of the late 1970s may enable the observation of any possible long term effects of the energy cost shock. Some simply converted to less

expensive energy sources. According to the American Gas Association, over 600,000 households converted to gas between 1978 and 1979. While this conversion likely saved them up to 40 percent on home heating bills, it did not increase the efficiency of their homes.

Results from the National Interim Energy Consumption Surveys conducted in 1977 and 1978 further address the issue of delayed effects. The survey confirmed that households continued to make changes several years after the 1973 cost increase; these changes, however, remained modest and still lacked significant investment. In fact, 60 percent of responding households reported not spending a single dollar on conservation over the prior two year period. The characteristics of the households that did make investments suggested that these investors benefited the most by increasing the efficiency of their homes. They tended to be younger, lived in older homes, had higher incomes and used larger amounts of home energy than the group of non-investors. Younger households have a greater likelihood of remaining in their home long enough to reap any benefits of energy efficiency investments. Furthermore, older homes likely have potential for efficiency improvements. Finally, households with higher incomes are more likely to have the financial resources necessary to make investments in efficiency. The most common investments made by households included installing storm doors, installing storm windows, and insulating attics. About 10 percent of households partook in each activity (Frieden and Baker, 1983).

The overall story from the oil shock in 1973 is that the majority of households respond to rising home energy costs by taking actions to reduce energy consumption to offset higher energy prices. However, the majority of these actions are going to be minor lifestyle changes that produce quick results, require no investment, and do not increase the energy efficiency of their home.

The Demographics of Home Energy Conservation

To determine how household responses differ based on demographic characteristics, the Energy Information Administration's Residential Energy Consumption Surveys (RECS) from 1997 and 2001 were used. Over the four years between surveys, home energy costs rose roughly 13 percent. The RECS is a household survey that had a sample size of nearly 6,000 households in 1997 and almost 5,000 households in 2001. Comparing household energy consumption from 1997 and 2001, it is evident that households were eager to reduce consumption. Households that reported higher overall levels of energy use had higher incomes and an older householder (household head), and these households demonstrated the most substantial reductions in energy

consumption following the cost increase. Unfortunately, the data do not show a differentiation between the portion of consumption reduction that is attributable to lifestyle changes and the portion that is a result of investments in efficiency.

Looking at the home energy consumption patterns by household income, it is clear that the greatest reductions took place in households with higher incomes. As Exhibit 3 illustrates, from 1997 to 2001 households with incomes between $40,000 and $75,000, and $75,000 or more reduced the average BTUs used per square foot by roughly 22 percent and 19 percent, respectively. While the households with higher incomes recorded lower average BTUs used per square foot, their aggregate levels of BTUs used were much higher than the lower income households. Additionally, it is worth mentioning that the results are not linear, as the lowest income group reported energy consumption reductions of over 16 percent. However, the means by which households in different income categories achieved these reductions probably differed.

Exhibit 3. From 1997-2001, Greater Reductions in Energy Consumption by Households with Higher Incomes

Household Income	1997 (Average BTUs used per sq. ft.)	2001 (Average BTUs used per sq. ft.)	1997-2001 % Change
<$20,000	72.9	61.0	-16.4
$20,000-$40,000	67.3	58.4	-13.2
$40,000-$75,000	62.3	48.7	-21.9
$75,000+	54.3	43.9	-19.3
All Households	66.4	53.6	-19.2

Source: tabulations of the Residential Energy Consumption Surveys, 1997 and 2001

Households with the highest incomes were able to achieve the greatest reductions on a per square foot basis. As the highest aggregate users of home energy, they clearly had the motivation to decrease their home energy use. Furthermore, with their higher incomes, they were more apt to have the financial resources necessary to make investments in conservation. As a result, higher income households probably accomplished their consumption reductions through a combination of lifestyle changes *and* undertaking energy conservation investments. On the

other end of the income spectrum, low income households in all probability concentrated on making lifestyle changes to lower their home energy bills. They likely turned down their thermostats and threw on an extra sweater to combat the rising home energy costs.

Performing a similar analysis by age of householder demonstrated that households with householders aged 45-54, 55-64 and 65 or older exhibited larger decreases in home energy use than younger householders. Households with householders aged 45-54 and 55-64 are most likely in their peak earning years. Therefore, the corresponding 21 percent and 24 percent reductions in average BTUs used per square foot by these households (Exhibit 4) are probably picking up the income effects discussed in the preceding paragraph. Similar to higher income households, households in these age groups (45-54 and 55-64) are probably combining lifestyle modifications and efficiency investments to obtain such substantial energy cutbacks. However, the near 22 percent decline in the average BTUs used per square foot by senior householders is certainly more of a necessity. More telling is the fact that across all age categories, senior householders demonstrated the largest reduction in the average *total* BTUs used.

Frequently of lower incomes, senior householders would expectedly feel the effects of the 13 percent increase in home energy costs experienced from 1997 to 2001. To compensate for the rising energy costs, they would minimize their home energy use. Moreover, earlier research suggests that older householders are presumably going to accomplish these reductions through changes in their lifestyles rather than investments in energy efficiency.

Exhibit 4. Substantial Consumption Decreases Among Older Householders

Age of Household	1997 (Average BTUs used per sq. ft.)	2001 (Average BTUs used per sq. ft.)	1997-2001 % Change
<25	72.5	63.4	-12.7
25-34	67.5	55.1	-18.4
35-44	64.3	55.5	-13.7
45-54	65.5	51.6	-21.2
55-64	67.0	50.7	-24.3
65+	66.5	52.0	-21.8
All Households	66.4	53.6	-19.2

Source: tabulations of the Residential Energy Consumption Survey, 1997 and 2001

Households in the Northeast and Midwest, regions where average household energy use is higher, demonstrated the largest reductions in home energy consumption (average BTUs/sq. ft.) of 23 and 26 percent, respectively. Meanwhile, households in the South and West revealed corresponding reductions of only 12 and 14 percent.

In general, during this period of rising home energy costs, the households that used the most energy were also the ones who cut back the most. Because higher users tend to have higher incomes, these households could also best afford to invest in energy saving activities. However, some of the sharpest drops in consumption came from households who probably couldn't afford much in the way of efficiency investments, such as senior citizen households. Also, younger households with a higher potential for mobility may not have much incentive to make such investments given a shorter payback period.

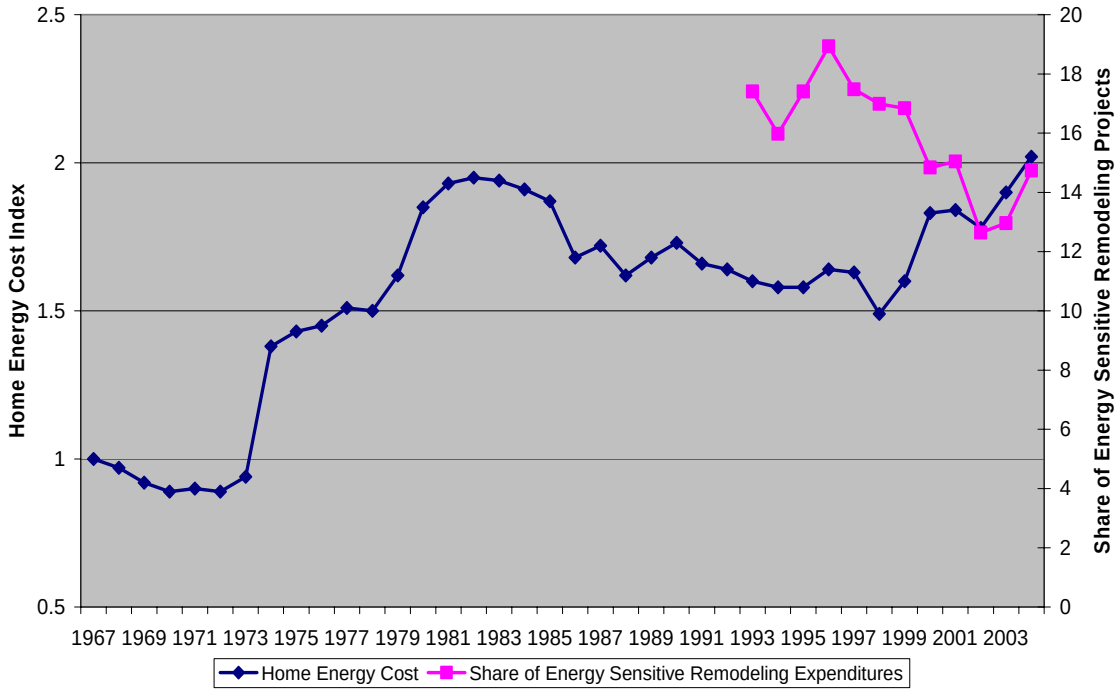
Remodeling Activity and Home Energy Costs

With a general idea of how consumers have historically responded to home energy costs relative to their home energy consumption and investments in conservation, attention can be directed to the principal question of how rising home energy costs effect investments in energy efficient retrofits. Using the Census Bureau's C-50 data series, "Expenditures by Type of Job"

facilitated looking at the share of remodeling expenditures that are allocated to energy sensitive types of projects from 1993 to 2004. While it would have been preferable to analyze a longer time series, project specific data was not available until 1993, thus limiting the analysis. Expenditures on heating, ventilation and air conditioners, windows, doors, and siding were considered to be "energy sensitive"; as these home improvements are likely to have the greatest impact on home energy efficiency.

As demonstrated in Exhibit 5, home energy costs and the share of energy sensitive remodeling expenditures have not been following the same path in recent years. Over the 1993-2004 period, home energy costs were trending upward, while the share of energy sensitive remodeling was trending downwards. Furthermore, when the share of energy sensitive remodeling was at its highest in 1996, accounting for almost 20 percent of all remodeling expenditures, home energy costs were relatively low. Conversely, in 2002 the share of energy sensitive remodeling expenditures was at its lowest despite home energy costs moving up.

Exhibit 5. Home Energy Costs and Energy Sensitive Remodeling Projects Not Moving Together



Source: Energy cost index is based on cost of residential electricity, residential natural gas, imported oil and exported oil from the Energy Information Administration, indexed to year 1967=1.0. Energy sensitive share of remodeling projects calculated using the Census' C-50 data series: "Expenditures by Type of Job".

A simple correlation was run to see if home energy costs and energy sensitive remodeling activity were related, and if so, when and how. Correlating the two variables at the current year, and then testing lags of energy efficiency spending out seven years allowed the analysis of whether a cost increase would have more of an impact in future years rather than the year immediately following the price change. Historically, rising home energy costs have not led to immediate investments in efficiency, thus a relationship between energy sensitive remodeling expenditures and home energy costs would not be expected without lagging the data. The results of the correlation appearing in Exhibit 6 show that an increase in the cost of home energy does not generate an immediate increase in the share of energy sensitive remodeling. Again, this is consistent with what the literature and data from previous periods suggested—households are not making major investments in energy conservation directly following a home energy price increase.

Exhibit 6: Rising Home Energy Costs Not Generating Immediate Increases in Share of Energy Sensitive Remodeling

TIME	CORRELATION (Home energy costs and share of energy related remodeling)
Current Year	-0.71*
1 Year Lag	-0.72*
2 Year Lag	-0.67*
3 Year Lag	-0.31
4 Year Lag	0.12
5 Year Lag	0.54
6 Year Lag	0.57*
7 Year Lag	0.61*

*Indicates statistical significance at the 95% level.
Source: JCHS analysis of Census' remodeling data and Energy Information Administration's energy price data.

In fact, in the first several years following the cost increase, the correlation results show a significant negative relationship between home energy costs and the share of energy sensitive remodeling. These results suggest a counterintuitive conclusion: household spending on energy

efficiency investments actually declines when energy costs rise. An explanation might be that households defer planned replacements/investments until they have the ability to research those products that have the best energy saving potential.

However, this curiosity is likely a factor of the idiosyncratic nature of the time period for which the data represents. At the beginning of this period, the country was just coming out of a recession and interest rates were low, thus encouraging households to invest in high-end remodeling projects. To take advantage of favorable interest rates, households would likely concentrate on the larger more costly remodeling projects and worry less about increasing their home's energy efficiency. Therefore, the influence from the recovering economy could change the overall mix of remodeling projects.

Additionally, the end of the time period was a particularly strong time for remodeling in general. High home price appreciation and the continued low interest rates encouraged homeowners to invest large amounts into their homes. The resulting high level of remodeling expenditures could have a dwarfing effect on the amount of energy sensitive remodeling that was actually taking place.

While the share of energy sensitive remodeling expenditures did not appear to be increasing in response to home energy cost increases in the first several years following the cost change, a significant and positive relationship between the two variables was witnessed six and seven years after the increase. Not only are the results significant and positive, but the magnitudes of the coefficients displayed are also fairly strong, suggesting an increase in energy efficient investments at the time of replacement rather than instantly following the rise in energy costs. This is reasonable, as rather than replacing an energy sensitive system or its components, which still have a significant amount of life left in them in the wake of the cost increase, householders will wait until the life of the system or components are near their end. At the time of replacement, households are then more willing to spend more money to replace their unit and/or component, allowing them to upgrade and attain more efficiency for their home.

Conclusions

This analysis began with the intent to determine how rising home energy costs affect investments in energy efficient retrofits by consumers. By studying the pattern of home energy costs since the 1970s, both short and long term household responses to shocks in the cost of home energy, the observed effects of different demographic characteristics on the probability of

investments in efficiency, and the actual levels of expenditures on energy efficient retrofits in recent years, it can be concluded that the cost of home energy has only a limited impact on energy efficient retrofits. Furthermore, in the cases where the cost does influence investments, it takes several years for the effect to become visible. The results are not definitive and the analysis contains a number of caveats. For example, if high home energy prices are sustained then we may see increased investments in efficiency. Additionally, the effects may not be linear, and there may be a price threshold which would encourage more expenditure on efficiency. Different results may also be found if rising energy costs persist while the economy stays healthy and home values continue to increase. In this scenario, households may have more willingness to make improvements in their home, and invest in its efficiency.

Bibliography

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