Incremental/Hedonic Price Analysis: Potential as a Cost Effective Method of Tracking Market Progress over Time?

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ABSTRACT

Although it is a critical "indicator" for many energy efficiency programs, tracking market shares for efficient equipment is expensive and onerous. Sales (and even reliable shipment) data are – and will likely continue to be – difficult to obtain from retailers / manufacturers. The authors determined to explore the potential of alternative, parallel, and less expensive methods of indicating market progress that might monitor interim progress and allow expensive sales data to be collected less often. Basic economics (equilibria are reflected in sales and price) provided the authors with an idea to explore apparent price differentials as an additional tracking mechanism.

Skumatz Economic Research Associates, Inc. (SERA) developed a method to use a detailed statistical approach to examine the price premium associated with energy efficiency features and the Energy Star® logo on a range of appliances and residential lighting equipment. The goal was to monitor market progress in the premium associated with efficient equipment compared to standard equipment. The goal was to 1) track these changes and 2) monitor their relation to changes in other market indicators including market shares or sales, and models on display.

The net price premiums attributable to the Energy Star® logo (after controlling for the effects from other energy efficiency features) were estimated and tracked. The results showed that while the apparent differences for efficient measures are high, these differences (percent and dollar) decrease dramatically when the price differences and potentially value attributable to other features of the measure are accounted for. Results differed by appliance, and the varying results have different implications for the underlying programs and measures.

Introduction: The Energy Star® Program and Label

In 1992, the United States Environmental Protection Agency (EPA) initiated a voluntary product labeling program in order to promote the use of energy-efficient products and practices. Today, the program, known as Energy Star®, seeks to reduce the market barriers to the use of energy-efficient appliances by reducing the transaction costs associated with researching such appliances, as well as the risk of purchasing faulty or inefficient merchandise.

The U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) work with manufacturers to determine the levels of energy efficiency at which appliances should perform in order to receive the Energy Star® label. The Energy Star® program then promotes awareness of the significance of its label through ongoing public education efforts. While traditional energy and conservation programs attempt to encourage the adoption of more efficient technologies by offering discounts or other short-term incentives, the Energy Star® program attempts to alter the actual decision-making process used by residences and businesses when they purchase appliances.

Although the immediate goal of the Energy Star® program is the promotion of energy-efficient appliances, the program began as an effort to reduce greenhouse gas emissions. In

order to substantially affect emissions levels, the practices encouraged by the Energy Star® program are being promoted nationally. To evaluate the appropriate expenditure of public funds, reliable measures of market progress for appliances bearing the Energy Star® label are important.

A Proxy for Energy Star® Market Share Tracking?

A key market progress indicator that proves a struggle – and an expensive struggle – for virtually all Energy Star® evaluation and attribution work is tracking market share for energy efficient equipment. Tracking market shares for efficient equipment is expensive and onerous. Sales (and even reliable shipment) data are difficult to obtain, and the data are unlikely to become less expensive to obtain over time because there are few incentives for manufacturers, distributors, or retailers to share this information. Gathering periodic sales data from balky retailers, distributors, or manufacturers with concerns about privacy can take years, or, in fact, may never be realized. Although increases in market share for Energy Star® appliances are a direct and important progress indicator, utilities and agencies are forced to use imperfect data related to shipments rather than sales, or other proxies for the market share information. Shipments are generally recognized to be a poor proxy in the U.S. because even after shipments are made, the equipment can cross state lines to other distributors, and that poses a significant problem for state programs trying to track market share changes within their state.

The authors suggest that tracking changes in price differentials for energy efficiency (EE) equipment over time may be an attractive and useful substitute indicator of market progress. The goal of many product-related interventions is to "move the market forward", or essentially to speed up adoption of EE equipment to levels that would otherwise only be reached years into the future. There are two elements to reaching that future equilibrium of supply and demand: quantity and price. As quantity goes up, price falls. Although it has proven difficult to assess progress in quantity, the progress may be reflected fairly in price – and even if that end or goal price isn't known, decreases down the curve indicate market progress. As Energy Star® models become more plentiful, or market share increases, and as economies of scale in production improve, a reduction in the price premium associated with Energy Star® may be expected. While market share is the direct metric of interest, the approach suggested here is that price premiums represent a close, companion indicator that can be much more easily tracked and measured. States in the U.S. have spent literally millions of dollars trying to track sales of energy efficiency equipment. Retailers and manufacturers have been reluctant to share these data, citing business sensitivities/confidentiality, time, and other issues. Frankly, the businesses do not have an incentive or a payback from reporting the data; it does not help their bottom line and they are concerned that it provides information that will help their competitors. Even programs that require sales data as part of program partnership see variations in if and when partners report the data. The critical difference is that sales cannot be determined from walking into (a sample of) stores and observing; prices can, and it takes only a relatively short time to collect this unambiguous, publicly available data. This price approach can be used in addition to or to augment sales data – perhaps collecting sales data every second or third year, and price data annually for cost-efficiencies. However, if budgets cannot support sales data, the authors suggest the price work described here[1] may provide a useful indicator on its own.

[1] This approach, developed by SERA and described in this paper, is called "PriceTrak" © SERA 2006.

Complexities arise, however, in that prices reflect the price for a "bundle" of service and features in an appliance. Simple price comparisons are not sufficient for this purpose as the prices are muddied by differences in features that are not our focus. Economics suggests that an analysis of the "hedonic" price for the feature of interest would represent an appropriate technique to address this problem.

The possibility of price premiums for Energy Star® lighting and appliances was explored through a statistical review of on-site retailer survey results. The authors developed a list of appliances upon which the exploratory price analysis would be conducted, and used a combination of field work / mystery shoppers and Internet review to develop a detailed list of features that might be expected to affect price for each of the set of residential Energy Star® lighting and appliances.

Data were collected on prices and the wide range of variations in features for both Energy Star® and non-Energy Star® appliances and equipment. Price differences faced by shoppers are a key component of their purchasing decision; however, shoppers implicitly conduct a price comparison that accounts for and trades off a variety of factors making up the product bundle. While one item might be more expensive, it might be larger, or have more settings or other features that the potential buyer would find attractive. The challenge is to conduct a similar comparison incorporating features and price differences to gain a more complete understanding of whether the price premium we are most interested in – the premium associated with the Energy Star® label – is decreasing (perhaps due to economies of scale). We believe the statistical analysis method we used mimics the types of comparisons and decision-making by consumers.

Both simple and more complex analyses were conducted -- simple comparison of average prices and then a more complex multivariate regression method to control for differences in features other than Energy Star® that might also be expected to affect the price differentials.

The Implicit Price of Energy Efficiency and Energy Star®

As noted above, sales data detailing the quantities of Energy Star® appliances sold over time are difficult to obtain. However, assuming a mostly static demand schedule for Energy Star® merchandise, it should be possible to infer developments in the market share of such merchandise by:

- identifying whether there is a price premium evident for efficiency features or the Energy Star® label, and
- tracking "controlled" price premium changes over time.

Reductions in the premium may provide proxy indicators of market (and market share) progress. This approach gives rise to its own set of challenges. Energy Star® labeled appliances are generally more expensive then their unlabeled counterparts. Not all of the price difference, however, can be attributed to the Energy Star® label. Because manufacturers invest in substantial research and development in order to design and produce merchandise sufficiently energy-efficient to earn the Energy Star® label, they often attempt to recoup the costs of their investments by bundling their products with additional features that allow them to be sold at higher prices. Measuring the changes in gross price differentials between Energy Star® and non-

Energy Star® merchandise will not produce an accurate estimate of the direction and intensity of the trends in Energy Star® market progress.

To use change in price as a proxy for market progress, then, requires the measurement of only those components of the changes in gross price that can be attributed to the Energy Star® label. The incremental change in a good's price attributable to only one characteristic of that good (the price change after accounting for the other determinants of price) is known as the implicit, or hedonic, price. We estimated the implicit price of the Energy Star® label for several types of appliances using regression analysis on data we collected from stores and the Internet.

"Controlled" Price Analysis of Energy Star® Appliances

In general, Energy Star® appliances come at a premium. Table 1 below summarizes the price information from a sample of three categories of residential appliances. We conducted a price analysis of data on refrigerators, dishwashers, air conditioners, and clothes washers.

The data used for this study were collected from several large retail chain stores located in or around Boulder, Colorado. The data were collected during 2005 and cover a wide variety of appliances, and included price and several dozen quantifiable features of the appliances. The analytical results[2] for refrigerators, room air conditioners, and dishwashers are presented in this paper.

In general, Energy Star® appliances come at a premium. Table 2 below summarizes the price information from a sample of three categories of residential appliances – refrigerators, room air conditioners, and dishwashers. The top of Table 2 presents the raw price comparisons for the sample of appliances examined.

In each case, the Energy Star® appliances were more expensive on average. As discussed above, the gross price of Energy Star® equipment is not the best indicator of market progress. The price of such equipment is a function of a vector of characteristics, and changes in any characteristic can affect the overall price.

In order to isolate only the price changes associated with the Energy Star® label, we appliance price as a function of a laundry list of differences in features for the appliances – including the Energy Star® label. The detailed decomposition analyses and results for each appliance are presented in the bottom Table 2 and are described in the paragraphs below.

[2] Ordinary least squares and log linear models were tested and used for the analysis. All models take the form $P=a+bES+\Sigma_k c_k X_k+e$, where P represents price, ES is a dummy variable for Energy Star®, and X_i is the ith non-Energy Star® characteristic of the appliance in question. The coefficient on ES (b) represents the hedonic price.

Table 2. Results of Price Decomposition Analysis of Refrigerators and Air Conditioners

	Refrigerators	Air Conditioners	Dishwashers	Clothes Washers
Average price	$992	n/a	$438	$603
Energy Star® (ES)	$1,249	$362	$456	$802
Non Energy Star® (NES)	$599	$381	$360	$489
Average price difference (ES-NES)	$650	$19	$96	$313
Average gross percentage price premium for ES	109%	5%	27%	64%
Average effect of ES label on price after accounting for other factors	$251	$81	$0-12	$71
Average ES Effect after accounting for other factors (percent)	42%	22%	0-3%	15%
Most significant determinants of price	Energy Star®, Changeable color panel, Stainless steel finish, Water filter, Ice maker	Energy Star®, height, EER, room size features, multi-functions	Stainless outside finish, number of wash levels, electronic tap controls, number of cycles	Energy Star®, Capacity, Electronic Controls
Sample of Insignificant variables	Freezer location, Access type, size, temperature control, Adjustable shelves, Side by side, Manufacturing location, Warranty	Capacity, electronic thermostat, dehumifying feature, quick clean filter, others	Energy Star®, Quiet mode, Delay start, Energy saver setting, Cubic feet	Annual energy use, delayed start, special finish, capacity, cycles, depth, warranty, dimensions, temperature setting

Detailed Discussion of Results

The results for these appliances were selected because they illustrate different outcomes. A significant gross price differential exists for of the set of large appliances we examined. However, simple comparisons hide the effects of other differences in the equipment – for example, differences in size, features/ options, or other factors. A variety of Energy Star® programs are designed to affect the purchase decision, [3] which is made on a whole product basis. While consumers look at the entire price premium, they also consider tradeoffs in the array of features associated with those higher priced models and make decisions based on this joint assessment. Our analysis approach is well-suited to decomposing these effects and isolating the effect attributable to Energy Star®. This statistical analysis helps sort out the portion of the price premium that is due to the Energy Star® feature – a figure that the price shoppers may estimate in an *ad hoc* way as they shop and make purchasing decisions. The research demonstrates that our statistical approach is successful at separating out the impacts of factors beyond Energy Star®

[3] Through a variety of interventions, including broad advertising, point of purchase advertising, rebates, and other methods.

that may influence differences in Energy Star® vs. non- Energy Star® prices for energy efficient appliances or other equipment.

The results of this analysis are the "controlled" price premiums shown in Table 2. The results show the simple gross price comparisons and the price premiums that could be associated with the Energy Star® label, controlling for other differences. Findings evident from this table include:

- **Refrigerators**: A simple comparison of the refrigerators included in the sample was almost $600, or 109% more than standard models; however, after controlling for key features, the remaining price differential that appears to be attributable to Energy Star® is about $251 or a 42% price premium. The results showed that a number of factors were related to price, including finish, water filter, and other features. The other significant variables, as well as several of the insignificant factors, are listed in the Table 2.[4]
- **Washing Machines**: The most substantial determinants of the price of washing machines include whether they have electronic controls, along with capacity and other features shown in Table 2.[5] The results showed that the Energy Star® variable, after eliminating the effects of other factors, was responsible for a hedonic price difference of $71, a significant decrease from the gross price differential of $313. The percentage premium for the Energy Star® label decreased from 64% to 15% attributable to the Energy Star® label.
- **Dishwashers**: The results of the analysis of dishwashers are shown in Table 2. Features that had a significant effect on price included the exterior finish (stainless steel), number of wash levels and cycles, and others features.[6] Table 2 also shows that the gross price difference between the dishwashers in our sample that are Energy Star® qualified and those that are not is $96. After accounting for other features, the price premium associated with the Energy Star® variable is small and statistically insignificant, and the estimated price premium falls from $96 to $12 (or less), and from 27% to about 3% or less.[7] The apparent price differential for dishwashers started lower, and also fell after controlling for other features. The price premium associated with the Energy Star® label for dishwashers appears to be nearly zero.
- **Air conditioners**: Air conditioners had an increase in the price premium for Energy Star®. The results demonstrate that, after controlling for the price effects of non Energy Star® features, the controlled price differential associated with the Energy Star® label increases from $19 (US) to $81 (US) – a substantial increase. These results suggest that the even lower-end air conditioning units, with fewer features, carry the Energy Star® label; thus the average price difference between Energy Star® and standard units is obfuscated by the different bundles of efficiency and non-efficiency features available for

[4] Note that for this appliance, brand or its sister variable manufacturing location (close correlation) was not significant as a determinant of price.

[5] Note that for the analysis of clothes washers presented here, neither brand nor manufacturing location were significant as a determinant of price. In other analyses of this appliance, we have found this to be a significant explanatory factor.

[6] Note that for this appliance, brand or its sister variable manufacturing location (close correlation) was not significant as a determinant of price.

[7] While the sample size for non ES models for this appliance was relatively smaller than the ES sample size, these results are similar to results we conducted for another client that was based on a larger dataset and showed the price premium associated with ES for dishwashers was also zero.

air conditioners. However, there was an interesting pattern and interaction between the Energy Star® label and the EER rating. The effect from Energy Star® was positive ($81) and the effect from the efficiency rating was negative (-$64). The net of these two impacts remains negative (-$16). These seemingly contradictory coefficient estimates may be a sign of the success of the Energy Star® program's marketing – the label itself increases prices while less-recognizable measures of energy efficiency have a deleterious effect, or none at all.

Table 3. Summary of Price Difference Analysis

	Gross price difference	Gross price difference (%)	"Controlled" price difference	"Controlled" price difference (%)
Refrigerators	$650	109%	$251	42%
Air Conditioners	$19	5%	$81	22%
Dishwashers	$96	27%	$0-12	0-3%
Clothes Washers	$313	64%	$71	15%

Implications of the Results

Our analysis of the hedonic price of the Energy Star® label on several types of large appliances has demonstrated that, while the label makes such consumer items more expensive, not all of the price difference can be attributed to it. Table 3 demonstrates for several appliances, that after accounting for intervening determinants of price, the premium associated with the Energy Star® label decreased substantially. The results for the various appliances, however, may have different interpretations.

- **Refrigerators**: The Energy Star® premium for refrigerators before accounting for other factors was 109% of the price of non-Energy Star® refrigerators. After controlling for other features, the price premium for Energy Star® fell to 42%. Manufacturers appear to be bundling additional features on Energy Star® models, causing their apparent prices to be higher than they would need to be if "comparable" models that were Energy Star® and non-Energy Star® were available (or obvious) to shoppers. However, the results still show a fairly substantial premium for Energy Star®, and program incentives may still be needed in the marketplace to generate or maintain increased sales of the efficient products.
- **Clothes Washers**: The results for clothes washers showed a decrease from a 64% premium to a 15% premium for the Energy Star® logo, after controlling for feature bundles. This is an important finding, because the apparent price difference for these clothes washers has been a considerable concern to program managers. The regression work shows that a good share of that price difference is due not the Energy Star® logo per se, but is due to manufacturers "loading up" other premium features on these machines to help recoup development costs, reap consumer surplus, and maximize profits on these models that currently have cachet. Again, the results show a fairly substantial "controlled" premium for Energy Star®, and program incentives may still be needed in the marketplace to generate or maintain increased sales of the efficient products.
- **Dishwashers**: The results for dishwashers are particularly noteworthy. The research shows that the price premium for the Energy Star® logo has become negligible. This may indicate that the market has become reasonably mature, and that interventions may no

longer be needed to encourage selection of Energy Star® models. This indicator might be adopted as a trigger for invoking an "exit strategy" for program interventions.

- **Air Conditioners**: Unlike the other equipment, air conditioners had an increase in the price premium for Energy Star® after controlling for the "feature bundling" effect. The results demonstrate that, after controlling for the price effects of non-Energy Star® features, the controlled price differential associated with the Energy Star® label increases from $19 (US) to $81 (US) – a substantial increase. These results suggest that the even lower-end air conditioning units, with fewer features, carry the Energy Star® label; thus the average price difference between Energy Star® and standard units is obfuscated by the different bundles of efficiency and non-efficiency features available for air conditioners. Price may be the key driver in purchases of air conditioners, which may cause Energy Star® models to reduce "other" features to keep them price competitive.

Applications and Next Steps

This work has several applications. This price decomposition approach was first explored by the authors in the 1990s and has since been applied to work for several clients. Tracking price differentials over time is an important application of this work – and this indicator may be used instead of, or in addition to (and more cheaply than), market share.[8] For example, to save funds, it may be cost-effective to decrease the frequency of tracking market shares, and introduce between-period price analysis studies. Results from tracking for one client shows that price premiums associated with both appliances fell between the two years, potentially demonstrating market progress and indicated that the approach shows promise in providing an idea of how mature the market has become.

The values may also be compared between states or areas for evidence of relative market progress of maturity. The authors have conducted empirical price analysis work in states with and without high levels of Energy Star® program activity. In theory, price premiums for high-activity states should be lower than in states where less promotion of the Energy Star® label has taken place.

The values derived by an on-going series of these price decomposition studies can be compared to future studies of a similar nature to look for market effects measured in terms of decreasing price differentials from Energy Star® programs. The authors are monitoring this effect on an on-going basis (and comparing to other locations) and are collecting data on price and appliance / equipment features, in association with the periodic on-site data collection efforts conducted as part of program evaluation. This work has several applications.

- **Tracking market progress toward transformation.** Sales and market share data are very difficult and expensive to obtain (if they can be obtained at all). Using readily available market price data and information of features, a price decomposition analysis can provide an alternate source for information indicating progress in the market. Assuming that this indictor reflects similar market equilibrium conditions as market share, this proxy variable can provide tracking information in a way that is less expensive

[8] For one client, the authors have conducted work to track price premiums over the last two years, focused on just two appliances. The research indicated that price premiums associated with both those appliances fell between the two years, potentially demonstrating market progress and indicating that the approach shows promise in providing an idea of how mature the market has become.

and complicated to measure than maturity of the market, as reflected in a declining premium. Presumably, the lower the premium the lower the incremental manufacturing costs, the higher the market share (since consumers do not have to pay much extra for this feature), and the more the market resembles the long-run equilibrium, the market has moved forward and become more transformed. The results can possibly address the question of whether additional or continuing interventions are needed in the market, and how quickly the market is progressing toward transformation. In addition to comparisons over time, the work can be used to make comparisons to other states or areas to assess relative market progress between areas and possibly identify more and less successful intervention approaches.

- **Assessing need for new or continuing program interventions.** A high or continuing price premium may be an indicator that the market is not maturing on its own, or that additional interventions may be needed to assist in achieving market transformation – information that is fairly reliable and inexpensive to obtain through this method, and can augment information from process evaluations or assessments of barriers and logic. The price premium may implicitly reflect this "market state," though it may not address "why" and additional research may be needed.
- **Estimating appropriate incentive or rebate levels.** The "controlled" price premiums estimated through this approach provide guidance for identifying appropriate levels for appliance rebates to encourage purchase of efficient models. This is useful to program planners, and may be more reliable than rebate estimates derived form other methods. The information on the premium is useful as a reflection of the amount of a price rebate that might be needed to encourage consumers to purchase Energy Star® labeled appliances (or reflect the maximum threshold at which they would be indifferent). If consumers conduct similar tradeoffs of features vs. price as the statistical work assumes, a dollar amount equal to the premium associated with Energy Star® should reflect the maximum rebate needed to make consumers indifferent between the two models. This estimate makes several simplifying assumptions. The first is that the consumer assigns zero value to the stream of energy savings that they will receive in the future. If they assign a value to this stream, then the rebate could presumably be lower than the estimated associated price increment. Second, if they associate with the logo higher quality appliances, the rebate may be able to be set lower than the estimate. Third, if they assign differences in maintenance, the rebate may be lower than the price premium indicates.
- **Identifying market maturation.** A low or zero attributed price premium may prove a useful "trigger point" for helping to identify the point at which markets may have matures, and program exit strategies may be justified.

The authors are applying this approach to additional measures, and are tracking pricing and sales results for a number of appliances to allow comparison of the results to identify whether the method provides a parallel (and less expensive) tracking method. Finally, we are applying the work to commercial measures to explore applications in that sector.

Summary and Conclusions

This paper summarizes recent work using statistical methods to examine the portions of the apparent price differences for a variety of appliances that are attributable to efficiency labels or components of efficient measures. The work stems from research examining progress in market transformation. The goal was to monitor market progress in the premium associated with efficient equipment compared to standard equipment – and potentially track these changes (hopefully, according to logic, declining) over time. However, the incremental cost metric is always confounded by the fact that the "feature bundle" on appliances and lighting is not consistent (i.e., many efficient products are loaded up with other, high-end features). Based on work conducted by the authors some years ago, we adapted statistical models to decompose the price differentials for efficient and standard refrigerators, clothes washers, and dish washers. The authors used site visits and web searches to gather data on appliance prices and features for a set of efficient and standard models. The authors first examined apparent (raw) price differentials between efficient and standard models. Then, using statistical techniques to control for differences in features on the measures, the differences attributable to various features – and in particular to energy efficient features and logos -- were estimated.

The results showed that while the apparent (gross) price differences for efficient measures are high, the percentage and dollar differences decrease dramatically when the price differences statistically attributable to other features of the measure are accounted for. Results differed by appliance, and the varying results have different implications for the underlying programs and measures.

The work illustrates a promising approach for a variety of important applications in program planning and evaluation:

- tracking market progress within and between states or service territories, using a proxy variable that is less expensive and complicated to measure than direct indicators of sales or market share,
- identifying appropriate levels for appliance rebates to encourage purchase of efficient models, and
- identifying if markets are mature and program exit strategies may be justified.