Decomposing price differentials due to ENERGY STAR® labels and energy efficiency features in appliances: proxy for market share tracking?

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Abstract
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 regression 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. The work illustrates a promising approach for three 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.

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 US EPA and 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[1] attempts to alter the actual decision-making process used by residences and businesses when they purchase appliances.[2]

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. Gathering periodic sales data from balky retailers, distributors, or manufacturers with concerns about privacy can take years, or 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 US 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.[3]

It has been suggested that tracking changes in price differentials for energy efficiency (EE) equipment over time may be an attractive and useful substitute indicator of market progress.[4] 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[5], 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,[6] 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 US have spent literally millions of dollars trying to track sales of energy efficiency equipment.[7] 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.[8] Even programs that require sales data as part of program partnership see variations in if and when partners report the data.[9] 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.[10]

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, and were used in the analysis.[11]

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

1. And, of course, other traditional energy efficiency programs also try to change this process but may target other aspects of this process.
2. United States Environmental Protection Agency. June, 2003. Energy Star® -- The Power To Protect the Environment Through Energy Efficiency. <http://www.energystar.gov/ia/partners/downloads/energy_star_report_aug_2003.pdf>.
3. Obviously, this is a bigger problem in small states than larger ones.
4. Including 1999 research for Wirtshafter, Bordner, Kreitler, and Skumatz, "California Residental Retrofit and Repair Baseline Contractor Survey Summary Report", for the CBEE and PG&E, San Francisco, CA, March 12, 2000, and other work.
5. for practical and confidentiality-related reasons
6. And after consumer surplus has been gathered.
7. Most noteworthy would be the expenditures in California over the past years, which has spent hundreds of thousands of dollars annually to gather data on sales of residential (and other) equipment from individual dealers and distributors across the State.
8. Even after assurances regarding confidentiality.
9. For example, the data reported to the New York Energy Research and Development Authority (NYSERDA) see variations month to month based on which retailers reported their sales.
10. Drawing a well-designed sample of retailers to "walk through" and collect data would fairly easily result in a good analysis sample of prices and features. The issue is definitely more complicated for the case of commercial equipment. The sales and the pricing are less transparent and work through dealers, contractors, and many other routes.
11. The data for this study were collected in Colorado, which is not one of the active states for the ENERGY STAR® (ES) program, although it would receive impacts from the national program.

Table 1. Summary of Raw Price Differences for Appliances.

	Average Price non- ENERGY STAR®	Average Price ENERGY STAR®	Gross price difference*	Gross price premium (%)
Refrigerators	$599	$1 249	$650	109%
Clothes washers	$489	$802	$313	64%
Dishwashers	$360	$456	$96	27%

* Of course, the gross price difference is critically dependent on the mix of models from which data are collected, and even the number of ES vs. Non-ES models in the sample, which is one of the reasons a simple comparison is not meaningful. The statistical decomposition work pulls out effects due to specific features, and those are comparisons that are useful in making conclusions. The statistical work is less dependent on the specifics of the distribution of the sample, as long as there are enough models with enough variation in characteristics – and if there are enough ES and non-ES models in the sample.

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). 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 premium evident for efficiency features or the ENERGY STAR® label, and
- tracking price 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® labelled 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.

Price analysis of ENERGY STAR® appliances

In general, ENERGY STAR® appliances come at a premium. Table 1 summarizes the price information from a sample of three categories of residential appliances. We conducted a price analysis of data on refrigerators, dishwashers, and clothes washers. Table 1 presents the raw price data 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 attributed elements of the price difference to a laundry list of differences in features for the appliances – including the ENERGY STAR® label. The analyses and results for each appliance are described below.

REFRIGERATORS

We used an ordinary least squares (OLS) model to estimate the implicit price of the ENERGY STAR® label on refrigerators:

Price = Constant + b1*EnergyStar + b2i*Xi + error

where,

EnergyStar = 1 if the appliance is ENERGY STAR®;
0 otherwise;

Xi = other features of the appliance, for example cubic feet of the appliance, side by side feature, posted energy use for the appliance, etc.

The results showed a number of factors were related to price, including finish, water filter, and other features. The other significant variables, as well as the insignificant factors, are listed in the Table 2.[12] Of more interest is the parameter estimate for the ENERGY STAR® variable. After stripping away the price impacts associated with other features and

Table 2. Results of Price Decomposition Analysis of Refrigerators.

	Refrigerators
Average price	$992
ENERGY STAR®	$1 249
Non ENERGY STAR®	$599
Average price difference (ES-NES)	$650
Average gross percentage price premium for ES	109%
Average effect of ES label on price after accounting for other factors	$251
Average ES Effect after accounting for other factors (percent)	42%
Most significant determinants of price	ENERGY STAR®, Changeable color panel, Stainless steel finish, Water filter, Ice maker
Insignificant variables	Freezer location, Access type, size, temperature control, Adjustable shelves, Side by side, Manufacturing location, Warranty
Table Note: The p value for the difference between the raw ENERGY STAR® and non-ENERGY STAR® prices is less than 0.001 with equal and unequal variances. The p value on the ENERGY STAR® variable for the "controlled" price premium is 0.0305.	

Table 3. Results of Price Decomposition Analysis of Clothes Washers.

	Clothes Washers
Average price	$603
ENERGY STAR®	$802
Non ENERGY STAR®	$489
Average price difference (ES-NES)	$313
Average gross percentage price premium for ES	64%
Average effect of ES label on price after accounting for other factors	$71
Average ES Effect after accounting for other factors (percent)	15%
Most significant determinants of price	ENERGY STAR®, Capacity, Electronic controls
Insignificant variables	Annual energy use, Delayed start, Special Finish, Capacity, Cycles, Depth, Warranty, Size (depth, height, width), Temperature setting
Table Note: The p value for the difference between the raw ENERGY STAR® and non-ENERGY STAR® prices is less than 0.001 with equal and unequal variances. The p value on the ENERGY STAR® variable for the "controlled" price premium is 0.003.	

identifying that portion associated with ENERGY STAR® the price premium dropped from a gross of $650 to a net of $251. The premium in percentage terms fell from 109% to 42%.

CLOTHES WASHERS

Our model for clothes washers was estimated in similar fashion:

Price = Constant + b1*EnergyStar + b2i*Xi + error

where,

EnergyStar = 1 if the appliance is ENERGY STAR®; 0 otherwise;

Xi = the posted annual kWh use for the appliance; topload, controls, cycles, or other features.

Table 3 summarizes the results of the analysis of clothes washers. The most substantial determinants of the price of washing machines include whether it has electronic controls, along with capacity and other features shown in Table 3.[13] 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

Finally, the price of dishwashers using the following model:

Price = Constant + b1*EnergyStar + b2*Quiet + b3*Delay-Start + b4*ESavingSet + b5*ETapBtn + b6*Cycles + b7*WshLv + b8*CubicFt + b9*Stnless

where,

EnergyStar = 1 if the unit is ENERGY STAR®, 0 otherwise;

Xi = quiet or silent mode; delayed start feature, electronic tap buttons, number of cycles offered on the unit; number of

12. Note that for this appliance, brand or its sister variable manufacturing location (close correlation) was not significant as a determinant of price.
13. 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.

Table 4. Results of Price Decomposition Analysis of Dishwashers.

	Dishwashers
Average price	$438
ENERGY STAR®	$456
Non ENERGY STAR®	$360
Average price difference (ES-NES)	$96
Average gross percentage price premium for ES	27%
Average effect of ES label on price after accounting for other factors	$0-12
Average ES Effect after accounting for other factors (percent)	0-3%
Most significant determinants of price	Stainless outside finish, Number of wash levels, Electronic tap controls, Number of cycles
Insignificant variables	ENERGY STAR®, Quiet mode, Delay start, Energy saver setting, Cubic feet
Table Note: The p value for the difference between the raw ENERGY STAR® and non-ENERGY STAR® prices is 0.1083 for equal variances, and 0.1220 for the case of unequal variances. The ENERGY STAR® variable for the "controlled" price premium is not significantly different from zero.	

Table 5. Summary of price difference analysis.

	Gross price difference	Gross price difference (%)	Hedonic price difference	Hedonic price difference (%)
Refrigerators	$650	109%	$251	42%
Clothes washers	$313	64%	$71	15%
Dishwashers	$96	27%	$0-12	0-3%

wash levels offered on the unit; the unit's volume; stainless steel exterior, and other features.

The results of the analysis of dishwashers are shown in Table 4. Features that had a significant effect on price included the exterior finish (stainless steel), number of wash levels and cycles, and others listed in the Table.[14] The Table 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.[15]

Results

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, [16] 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. Regression analysis 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 the regression approach is successful at separating out the impacts of factors beyond ENERGY STAR® 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 5. 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:

- 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.
- Similarly, for clothes washers, a simple price comparison indicates a $313 price premium (64%). Again, after controlling for key features the remaining price differential attributable to ENERGY STAR® is about $71, or 15%.
- The apparent price differential for dishwashers started lower, and also fell after controlling for other features. The hedonic price for the ENERGY STAR® label for dishwashers appears to be nearly zero.

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

14. Note that for this appliance, brand or its sister variable manufacturing location (close correlation) was not significant as a determinant of price.
15. 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.
16. Through a variety of interventions, including broad advertising, point of purchase advertising, rebates, and other methods.

be used instead of, or in addition to, (and more cheaply than) market share. 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.

The values may also be compared between states or areas for evidence of relative market progress or maturity. For example, the data in this study are from a state without a high level of ENERGY STAR® activity. The authors have also conducted work for very active states, and the hedonic price differences tended to be lower in those active states than the results in this paper. The theory would be that the premiums for ENERGY STAR® might be lower in more active areas if more of those models have been ordered, etc.[17] This comparison may represent a way to gauge relative program progress between areas.

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 the ENERGY STAR® program. Monitoring this effect on an on-going basis (and comparing to other locations) will require collecting data on price and appliance / equipment features, presumably in association with the periodic on-site data collection efforts conducted as part of program evaluation efforts. The results shown in Table 5 indicate that collecting data on prices and features can provide useful and potentially robust information to assist in isolating factors such as size, location, and ENERGY STAR® marketing efforts that contribute to the price differential.

Summary and implications

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 5 demonstrates, in several ways, that after accounting for intervening determinants of price, the premium associated with the ENERGY STAR® label decreased substantially. For example, 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%. The results for clothes washers showed a decrease from a 64% premium to a 15% premium for the ENERGY STAR® logo. 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.

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,[18] 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.

The 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 on features, a price decomposition analysis can provide an alternate source for information indicating progress in the market. Assuming that this indicator reflects (the other side of) similar market equilibrium conditions as market share, this proxy variable can provide tracking information in a way that is less expensive and less complicated to measure than direct indicators of sales or market share. The results can be used to track market progress and identify the relative 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 additional for this feature), and the more the market resembles the "long term" 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 vs. 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 reliably and inexpensively obtained 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", although it may not address "why" and additional research may be needed.

Estimating appropriate incentive / rebate levels: The hedonic prices estimated through this approach provide guidance for identifying appropriate levels for appliance rebates to encourage purchase of efficient models.[19] This is useful to program planners, and may be more reliable than rebate

17. It is also theoretically possible that if ENERGY STAR® models become so popular in states with heavy promotion, that the prices may be bid up, but that would be something worth examining.

18. "Mature" may not be indicated by a zero price premium, but would presumably be indicated by a premium that is considerably lower than the increment represented early in the ENERGY STAR® product cycle or technology cycle, before economies of scale are realized. The "long run" price differential –probably related to purely technological and manufacturing differences – would be the premium. However, as technology continually changes, and the technologies that are labeled ENERGY STAR® will also upgrade and evolve. This will also need to be taken into account in identifying a more mature market position or the ultimate definition of "market transformation".

estimates derived from 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® labelled 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 simplifying assumption is that the consumer assigns zero value to the stream of energy savings they will receive in the future. If they assign a value to this stream, then the rebate could presumably be lower than the estimated hedonic price. Second, if they associate the logo with higher quality appliances, the rebate may be able to be set lower than the estimate. Third, if they assign differences in maintenance – and in this case, maintenance may be perceived to be higher or lower based on feedback from the market – the dollar rebate may be able to be adjusted to reflect this difference. In any case, the estimated hedonic price is useful for setting rebate levels when designing programs.

Identifying market maturation: A low or zero attributed price premium may prove a useful "trigger point" helping identify the point at which markets may have matured[20] and program exit strategies may be justified.

In summary, the work demonstrated interesting results for several key ENERGY STAR® appliances, and given the high level of funding that has been dedicated to these programs across the U.S., applying this method may be an appropriate addition to the evaluation toolkit for these programs. The research indicates this technique has several useful applications in program planning and evaluation.

19. A discussion would be needed to determine whether the premium should be priced based on the coefficient associated strictly with the ENERGY STAR® logo, or the premium associated with the logo plus the premium associated with any energy use features (e.g., some of the results showed significance associated with the energy use label value, or "yellow sticker"). However, these premiums are both estimated using this methodology.
20. Although as noted earlier, some discussion of the definition of mature market would be needed as definitions of qualifying technologies and appliances change and technology evolves.