Evidence of Progress – Measurement of Impacts of Australia's S&L Program from 1990-2010

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Abstract

Australia first put categorical energy efficiency labels on residential appliances in the mid-1980s, and the first Minimum Energy Performance Standards (MEPS) for refrigerators was implemented in 1999. Updated in 2005, these MEPS were aligned with US 2001 levels. Considered together, these actions set Australia apart as having one of the most aggressive appliance efficiency programs in the world. For these reasons, together with good data on product sales over time, Australia represents a potentially fruitful case study for understanding the dynamics energy efficiency standards and labeling (EES&L) programs impacts on appliance markets. This analysis attempts to distinguish between the impacts of labeling alone as opposed to MEPS, and to probe the time-dependency of such impacts.

Fortunately, in the Australian case, detailed market sales data and a comprehensive registration system provides a solid basis for the empirical evaluation of these questions. This paper analyzes Australian refrigerator efficiency data covering the years 1993-2009. Sales data was purchased from a commercial market research organization (in this case, the GfK Group) and includes sales and average price in each year for each appliance model – this can be used to understand broader trends by product class and star rating category, even where data is aggregated. Statistical regression analysis is used to model market introduction and adoption of high efficiency refrigerators according to logistic adoption model formalism, and parameterizes the way in which the Australian programs accelerated adoption of high-efficiency products and phased out others. Through this analysis, the paper presents a detailed, robust and quantitative picture of the impacts of EES&L in the Australian case, but also demonstrates a methodology of the evaluation of program impacts that could form the basis of an international evaluation framework for similar programs in other countries.

Introduction

In attempts to address climate change and carbon emissions, Australia addressed energy efficiency improvements by first putting categorical energy efficiency labels on residential appliances in the mid-1980s[1]. Also promoting consumer information, this label uses stars to rate the energy efficiency of the product and promotes differentiation on the basis of energy and consideration of total life cycle costs. The original label, established in 1986, and its 2000 revision are illustrated below.

[1] Holt, S., Weston, J., Foster, R. (2011). The Australian Experience of

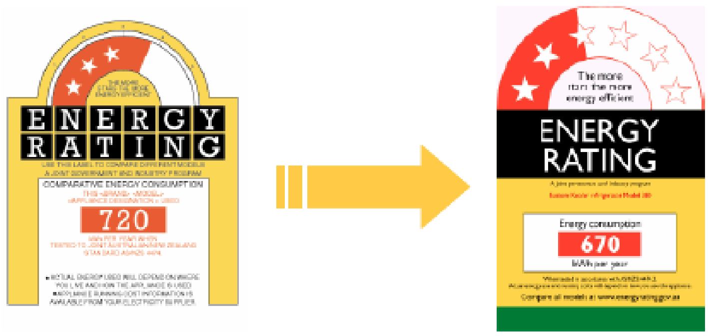

Figure 1: Original label (1986) and 2000 revision

The energy labels are simple but very salient for consumers, and now have extremely high recognition and credibility with consumers in Australia. This label was one of the first categorical labels for energy efficiency used in the world and the concept has now been successfully adopted in all regions, except North America. The goal of the Minimum Efficiency Performance Standards (MEPS) is to accelerate energy efficiency adoption rates for appliances in advance of what the market will otherwise deliver with energy labeling alone. Such standards were first implemented in Australia for refrigerators in October 1999, and later revised in January 2005. As mandated by the Australian legislature, MEPS allow the Australian government to prohibit manufacturers from selling their products if they do not meet the performance standards. In order to facilitate adoption of new more stringent standards, the 2005 MEPS were harmonized with the American 2001 standards, at the time considered to be the most stringent in the world. Around the same time, in 2000, the efficiency rating algorithm was rescaled to better represent the relationship between efficiency and volume and to deal with extensive “market creep” where large numbers of models had achieved fairly high star ratings in the 14 years since labeling began. Considered together, these actions set Australia apart as having one of the most stringent appliance efficiency programs in the world, along with the United-States and Canada. For these reasons, the Australian example represents an illustrative case study for energy efficiency standards and labeling (EES&L) program dynamics and how they impact appliance markets. This paper analyzes Australian refrigerator efficiency data covering the years 1993-2009.

Statistical regression analysis is used to model market introduction and uptake of high efficiency refrigerators according to logistic adoption model formalism, and thereby parameterize the way in which the Australian programs accelerated adoption of high-efficiency products and phased out others. Through this analysis, the paper demonstrates a methodology of the evaluation of program impacts that could form the basis of an international evaluation framework for similar programs in other countries.

History of Refrigerator MEPS and Labeling in Australia

The 1999 Australian MEPS were announced three years prior in 1996, and the 2005 MEPS was announced in 2001. A different approach for determining the standards was used for both the determination of the 1999 and 2005 MEPS levels: the 1999 MEPS levels were determined by using a statistical approach in which 1992 market data was used to evaluate the relationship between energy and adjusted volume of the appliance. The original approach sought to draw a line below 40% of available models in each of the nine refrigerator categories. However, this statistical method was replaced in 2001 with what is referred to as the “international harmonization” approach, in which the Australia MEPS were updated to align with American 2001 MEPS levels for refrigerators[2]. American MEPS levels in 2001 were considered to be the most stringent, and by adopting such standards, Australia eliminated trade barriers and set out to achieve ambitious energy efficiency goals. Meeting these goals was a remarkable achievement for Australia; in October 2000 not a single refrigerator or

[2] Holt, S., Weston, J., Foster, R. (2011). The Australian Experience of Minimum Product Standards.

freezer on the market met the proposed MEPS schedule which was intended to begin in 5 years[3]. A sparsely populated country like Australia is rarely in a position to unilaterally set MEPS to be the best in the world; it must rely on larger economic blocks like North America and Europe to invest the resources to push the market towards the technological limits, thus allowing smaller markets like Australia's to follow in their wake.

In addition to the new MEPS implementation approach, the energy labeling rating algorithm was re-scaled in 2000 for all labeled appliances (and again in 2010 for refrigerators, but the impact of this label change is beyond the scope of this paper). The original algorithm developed in 1985 and introduced in 1986, used an approach to calculating the star rating based on energy consumption and adjusted volume of the appliance. This method used a linear relationship that unfairly biased larger appliances and had a fixed energy step per additional star. The revised algorithm also calculates the star rating based on adjusted volume but with a fixed energy offset, removing some of the volume bias in the older scheme. The new scheme also introduced the concept of a geometric progression, which effectively fixed the percentage energy reduction per additional star to be constant across all star ratings (reflecting the fact that additional energy reductions are harder to achieve as absolute energy declines). The old algorithm had six possible star ratings ranging from 1 (worst performing) through 6 (best performing), while the new system retained 1 to 6 stars but included half star intervals (giving a total of 11 possible grades). The label itself was redesigned so the unearned stars were now visible in outline. As a result of the change, the star ratings prior to 2000 were phased out. However, the data used in this analysis solely uses the new algorithm, where data prior to 2000 was converted from the old algorithm to the new one. The consistent use of the new algorithm established in 2000 illustrates the evolution of domestic refrigerator technologies while labeling categories are held constant.

Methods

The Data

This paper analyzes Australian refrigerator efficiency data covering the years 1993-2009. Sales data was purchased from a commercial market research company (GfK Group) and the data was cross matched to a comprehensive registration database by Energy Efficient Strategies on contract to the Australian government as part of its ongoing monitoring and evaluation program. The purchased sales data includes sales by model and average price paid by model in each year. The registration database included all technical details for each model such as tested energy, volume, features, configuration and other critical data. Cross matched model data was then aggregated into product categories and star rating. While there are currently 10 categories of refrigerators and freezers on the Australian market (called Groups), this analysis focuses on the four categories of refrigerators described as combined refrigerator-freezers, which constitute approximately 80% of the Australian refrigerator market[4].

The data, used to evaluate the impact of the 1999 and 2005 MEPS, separated into 3 time periods delineated by the introduction of new MEPS.

- Period 1: 1993-1996
- Period 2: 2000-2003
- Period 3: 2005-2009

Statistical regression is used on the market share data of each star rating level for each time period to determine the rate of uptake of efficiency improvement. The regression parameters are then used in conjunction with the logistic formalism to develop S-curves representing the cumulative market share across efficiency levels.

The 1999 MEPS were introduced in the last annual quarter (October) and therefore the pre-1999 MEPS period is considered to be from 1993 through 1999. However, the 2005 MEPS revision occurred in January of that year, so the post-2005 MEPS period includes 2005 and is considered to

[3] Harrington, L., & Holt, S. (2002). Matching World's Best Regulated Efficiency Standards: Australia's Success in Adopting New Refrigerator MEPS
[4] Energy Efficient Strategies, 2010

be 2005 – 2009. One of the important observations of our research is that there was significant movement in the market in advance of the 1999 and 2005 MEPS as a result of announcements of the regulations in before their implementation. For this reason, market behavior in these 'transition periods' before each MEPS implementation date is not well described by an S-curve and therefore these years (1997-1999 and 2004) were excluded from the regression. The exclusion of the transition years is results in an increased R^2, confirming the rationale for their exclusion.

The Market Share Model

Original Market Share Data and Cumulative Market Share

The data includes sales and average price in each year for each product category and each star rating, which ranges from 1 to 6 stars in half star intervals. This data was used to obtain the market share percentage in each year of each efficiency rating. The market share percentage for each efficiency level indicates the percentage of the Australian market for residential refrigerators of each efficiency level. For example, if a 4-star refrigerator has a market share of 15% in 1993, this means that in 1993 4-star refrigerators only made up 15% of the total residential refrigerator market in Australia.

For this analysis, the cumulative market share across efficiency levels is used as the principal variable to evaluate the impacts of changes in efficiency over time. This cumulative market share of a specified efficiency level represents the additive value of the market shares of all of the star ratings equal to or greater than the specified star rating. For example, if the cumulative market share in 1993 for a 3-star appliance is 3.4%, than all appliances rated 3.0 or greater constitute a combined market share of 3.4%. The cumulative market share across star efficiency levels appears to be the best metric to evaluate the energy efficiency improvements because energy efficiency technologies that are used in one level are assumed to apply to higher levels as well[5].

Model Formalism

The general form of the cumulative market share relationship with time follows an S-shaped sigmoid function and is best described by the function expressed below[6]:

$$F(t) = \frac{1}{1 + e^{-q*(t-t_0)}}$$

- where *F(t)* indicates the cumulative market share of a specified efficiency level for a specific year, *t*;
- t represents the year of the market share data;
- t_0 is such that $F(t_0)$ = 0.5;
- and *q* is the adoption rate of a specific efficiency level.

This analysis uses the logistic model because it can easily be converted to a linear function, allowing for a linear regression analysis of the data and determination of the model parameters[7]. By definition, the logistic function has a maximum of 1, at which point market saturation is reached. The minimum of the function is 0, at which point the product has no share of the market. While the function has several parameters, those determined by the statistical regression are *q*, the rate of adoption, and *c*, the constant of the regression. The remaining parameters are functions of those determined by the regression.

[5] Van Buskirk, R. (2012). *An Adoption Curv-Fitting Method Estimating Market Efficiency Improvement and Acceleration*
[6] McNeil, M., & Letschert, V. E. (2010). Modeling Diffusion of Electrical Appliances in the Residential Sector
[7] Van Buskirk, R. (2012). *An Adoption Curve-Fitting Method Estimating Market Efficiency Improvement and Acceleration*

Analysis of the Data

The data is linearized to facilitate estimation of the cumulative market share with a function that can be estimated linearly. The linearization allows regression analysis to be performed and to estimate the values of the parameters *q* (the slope) and *c*, the constant.

A plot of the raw, untransformed cumulative market shares is provided below. The data used for the remainder of the analysis was rescaled using the logistic distribution described above.

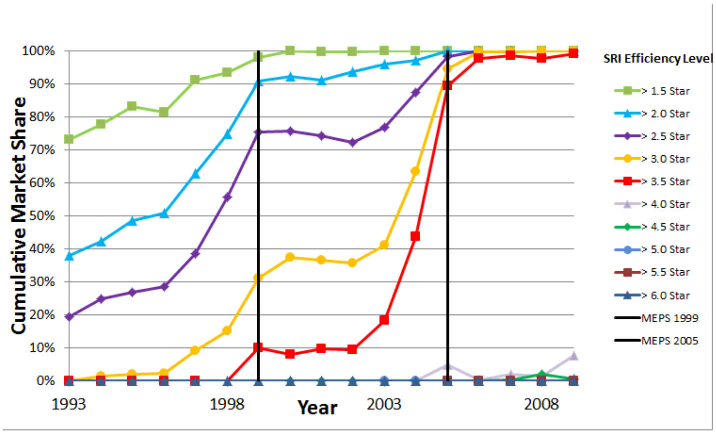

Figure 2: Raw Data of Cumulative Market Share of Australian Refrigerator-Freezers

Estimation of Model Parameters: q and t_0

In order to fit the data a regression is performed for each year on each of the 3 segments of the data delineated above to determine the slope of the trend line. The slope of the regression, representing the rate of adoption of new appliances, is represented by *q*. While the constant *c* does not appear as a parameter of the model, it is used to determine the value of t_0, the year at which the cumulate market share is 50% (i.e. the inflection point of the S-curve). Following from the fact that t_0 is such that $F(t_0) = 0.5$, we find that $t_0 = \frac{-c}{q}$.

Table 1: Summary of Regression Parameters and Statistics

	SRI EFFICIENCY LEVEL										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
VALUES OF q											
Period 1	-	0.17	0.19	0.16	0.19	-	-	-	-	-	-
Period 2	-	0.81	0.25	0.01	0.04	0.28	0.92	0.43	-	-	-
Period 3	-	6.69	5.65	1.74	1.62	0.58	-0.01	0.10	1.17	-	-
VALUES OF C											
Period 1	-	-346.4	-369.6	-323.6	-380.5	-	-	-	-	-	-
Period 2	-	-1624.2	-507.0	-15.2	-83.8	-567.2	-1841.8	-863.0	-	-	-
Period 3	-	-13400.3	-11329.6	-3493.4	-3238.0	-1166.7	16.4	-202.5	-2345.7		
VALUES OF t_0											
Period 1	-	1986.9	1995.6	2001.4	2015.8	-	-	-	-	-	-
Period 2	-	1993.8	1990.9	1867.3	2013.5	2008.9	2005.9	2012.1	-	-	-
Period 3	-	0.0	2004.4	2002.4	2002.8	2000.5	2073.4	2027.8	2012.2	-	-
R2											
Period 1	-	0.76	0.98	0.89	0.99	-	-	-	-	-	-

Period 2	-	0.79	0.74	0.01	0.30	0.77	0.85	0.44		-	-
Period 3	-	0.84	0.52	0.93	0.95	0.76	0.01	0.66	0.90	-	-
Std. Err. of q Coefficient											
Period 1	-	0.07	0.02	0.04	0.02	-	-	-	-	-	-
Period 2	-	0.42	0.11	0.05	0.05	0.11	0.27	0.34	-	-	-
Period 3	-	2.05	3.16	0.28	0.21	0.19	0.05	0.04	0.38	-	-
Std. Err. Of constant											
Period 1	-	136.75	41.14	78.79	31.48	-	-	-	-	-	-
Period 2	-	837.77	213.24	109.05	90.45	217.02	539.59	680.11	-	-	-
Period 3	-	4115.91	6337.04	554.94	425.39	381.25	96.50	83.03	765.87	-	-
t-statistic											
Period 1	-	2.54	8.98	4.09	11.96	-	-	-	-	-	-
Period 2	-	1.95	2.39	0.15	0.92	2.60	3.41	1.26	-	-	-
Period 3	-	-	1.79	6.31	7.63	3.07	-0.16	2.41	3.06	-	-

The results of the regressions for all efficiency levels are summarized in Table 1 (above). This table lists all of the regression parameters and regression statistics used in fitting the data to the cumulative market share model described above. For example, in the case of star efficiency level 2.0, the slope of the market share (represented by the value of *q*) in time period 1 is less than in periods 2 and 3. This indicates that the market share for appliances that have a 2.0 star rating or greater grows slowest in time period 1, then increases in period 2, and then increases down significantly in period 3.

Once that the values of *q* have been determined for each time period and each efficiency level, the logistic transformation is used to model the anticipated cumulative market share of each efficiency level. This model assumes that each new MEPS implementation (occurring in both 1999 and 2005) triggers the *q* value to change.

Cumulative Market Share Projections

This model produces ‘S-curves’, illustrating the changing cumulative market share value over time of each efficiency level. The S-curves are used to model three different historical scenarios. A description of the three scenarios follows:

- **Scenario 1**: No MEPS were implemented in either 1999 or 2005. This scenario models the cumulative market share if no MEPS had been implemented. This scenario is a counterfactual of the 1999 and 2005 MEPS. (The *q* value remains constant for each year in this scenario)
- **Scenario 2**: MEPS were implemented in 1999, but not in 2005. This scenario models the effect that the MEPS in 1999 had on the cumulative market share and estimates what the cumulative market shares would have been after 1999 assuming that no additional MEPS were implemented. This scenario is the second counterfactual.In this case, the *q* value for each year is the same period 2 and period 3, but different in period 1.
- **Scenario 3**: MEPS were implemented in both 1999 and 2005. This scenario models the effect that the MEPS had on the cumulative market shares. This scenario models the historical progression of cumulative market shares and closely resembles the actual data points. (In this case the *q* value is different in each time period for each year.)

As mentioned above, a change in MEPS policy such as the ones introduced in 1999 and 2005 are expected to trigger the value of *q* to change. A summary of the scenarios and the values of *q* that are used is summarized in the table below.

Table 2: Summary of Model Scenarios

Scenario	Description	Value of *q* parameter	Nbr. of Values of *q*
1	No MEPS	Constant *q*	1

2	MEPS in 1999	Value of *q* changes in 1999	2
3	MEPS in 1999 and 2005	Value of *q* changes in 1999 and 2005	3

Energy Efficiency Improvement

The goal of the cumulative market share projection is to evaluate the energy efficiency improvement and energy savings resulting from the 1999 and 2005 MEPS, as well as the rescaling of the labels in 2000 (which is effectively bundled into the 1999 MEPS change). The evaluation is based on the difference between the counterfactual scenarios (1 & 2) and the scenario that closely reflects actual historical changes (Scenario 3).

The energy efficiency improvement calculation is based on the comparative energy consumption (CEC), which corresponds to the energy that appears on the energy label. This energy consumption is measured in kWh/year and is used with the market share data to obtain a weighted average of the yearly energy consumption by energy star rating. The two steps in this calculation are: 1) Calculating the CEC for each star level for each year; 2) calculating the weighted average of the projected CEC by using the market share projections for each efficiency level for each star level. The equations below detail the calculation involved in the two steps mentioned above.

Comparative Energy Consumption

The refrigerator star rating algorithm[8] is:

$$SRI = 1 + \left[\frac{\ln \frac{CEC}{BEC}}{\ln(1 - ERF)} \right]$$

The terms from the equation above are defined as follows:

SRI is Star Rating Index (star efficiency level)
CEC is Comparative Energy Consumption (energy that appears on the energy label)
BEC is Base Energy Consumption (this is the line that represents the energy for a star rating of 1.0).
ERF is the Energy Reduction Factor (this is the energy reduction for each additional star).

The sales data analyzed provided the star rating. The sales by star rating, the CEC for each model, the average size and energy by star rating can also be calculated.

Weighted CEC

The *CEC* (label for annual energy) is weighted by the annual sales by model to obtain the yearly weighted average energy consumption for each star rating. The *CEC* for each efficiency level was then used in conjunction with the projected market share model to produce a projected counterfactual of consumed energy for each scenario.

Energy Savings

The energy savings are determined by calculating the difference between the weighted average energy consumption and the extrapolated weighted average energy consumption from the S-curves for both the 1999 MEPS and the 2005 MEPS. The difference is calculated as follows:

$$\begin{aligned} &Yearly\ Energy\ Savings\ from\ Scenario\ 2\ (1999\ MEPS) \\ &\qquad = (Projected\ Weighted\ Averave\ CEC\ from\ Scenario\ 2) \\ &\qquad - (Projected\ Weighted\ Averave\ CEC\ from\ Scenario\ 1) \end{aligned}$$

[8]Appliance Energy Consumption in Australia: Equations for Appliance Star Ratings.

$$
\begin{aligned}
&Yearly\ Energy\ Savings\ from\ Scenario\ 3\ (1999\ and\ 2005\ MEPS) \\
&\quad = (Projected\ Weighted\ Averave\ CEC\ from\ Scenario\ 3) \\
&\quad - \ (Projected\ Weighted\ Averave\ CEC\ from\ Scenario\ 1)
\end{aligned}
$$

Where the weighted average CEC is derived from the sales data and the projected weighted average CEC is derived from the S-curves.

Results

Market Share Projections

Cumulative Market Shares

Figure 4 illustrates the cumulative market share in Scenarios 2 and 3. The dotted line in the figures represents the counterfactual scenarios, the solid lines represent the model fit of the scenarios, and the points are the actual market share data points.

In Scenario 2 the counterfactual is considered to be the cumulative market share of the efficiency levels assuming that no MEPS had been implemented in 1999 or 2005 (Scenario 1); in Scenario 3 the counterfactual is considered to be the cumulative market share of efficiency levels assuming that MEPS had been implemented in 1999 but not in 2005 (Scenario 2).

The model produced the cumulative market share projections for 1993 through 2010 for all the efficiency levels in Scenario 1. Scenario 1, in which there was no MEPS in 1999 or 2005, illustrates that in 1993 the only efficiency levels that have a cumulative market share greater than 0 are the lower levels, such as the 1.5, 2.0, 2.5, and 3.0 star levels. Higher efficiency levels did not constitute any percentage of the market in 1993, and the model determines that they only entered the market after the first MEPS in 1999. The model indicates that efficiency star levels 3.5 through 6 would not been introduced to the Australian market if it were not for the MEPS in 1999.

The lower efficiency star levels, levels 1.5, 2.0, 2.5, and 3.0, are also determined by the model to reach or approach their saturation point by 2009. For example, the star levels of 2.0 or greater constitute close to 100% of the market in 2009.

Figure 4 illustrates the market impact for both Scenarios 2 and 3. As shown in time period 2 of the plot for Scenario 2 (left-hand panel), the projected cumulative market share for star efficiency levels 1.5 – 3.0 is greater than the counterfactual cumulative market share, implying that for these low efficiency star levels the MEPS resulted in an increase of cumulative market share.Higher-efficiency levels, such as star efficiency levels 3.5 and greater, have no counterfactual because they did not exist in 1993, the start year for the data and on which was based the model. Therefore, the impact of the MEPS introduced in 1999 was to increase the cumulative market share of mid-range efficiency levels (i.e. 2.5 and 3.0 stars) and phase in higher efficiency appliances (i.e. 3.5 stars – 6.0 stars). The right-hand panel of Figure 4 illustrates Scenario 3, in which the MEPS was implemented in both 1999 and 2005 (this reflects reality). The projected cumulative market share of lower efficiency levels in time period 3 increase above the counterfactual and reaches the market saturation point. This increase is the case for star efficiency levels 1.5 - 3.5, where the solid line can clearly be seen rising above the dotted counterfactual. While the cumulative market shares of levels 1.5 – 4.0 increases above the counterfactual, the market saturation point is only reached by star efficiency levels 1.5 – 3.5. The increase in cumulative market share is most likely the result of increasing market shares in the recently introduced higher efficiency star levels, such as 4.0 – 6.0. However, the MEPS in 1999 seem to have caused SRI efficiency level 4.0 to jump, but it is then surpassed by the counterfactual. Levels greater than 5.0 have a cumulative market share of zero because those levels do not yet exist.

The increase in cumulative market share of star levels 1.5 – 3.5 most likely results from the increase in level 4.0 and 5.0. As a result of this increase in cumulative market share for low-efficiency appliances, the market makes room for higher efficiency appliances. As expected, the 2005 MEPS results in the introduction of higher efficiency appliances to the Australian market.

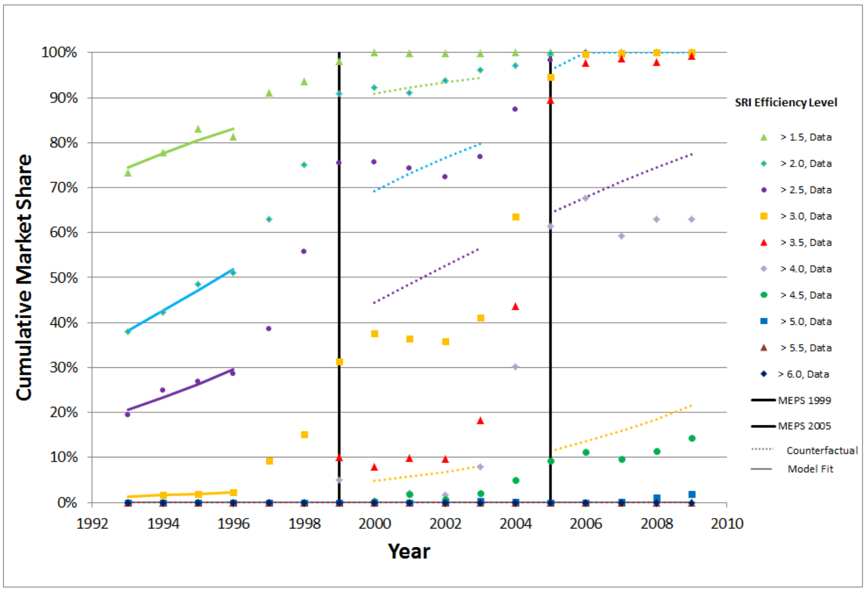

Figure 3: Adoption Curves of Australian Refrigerators-Freezers for Scenario 1

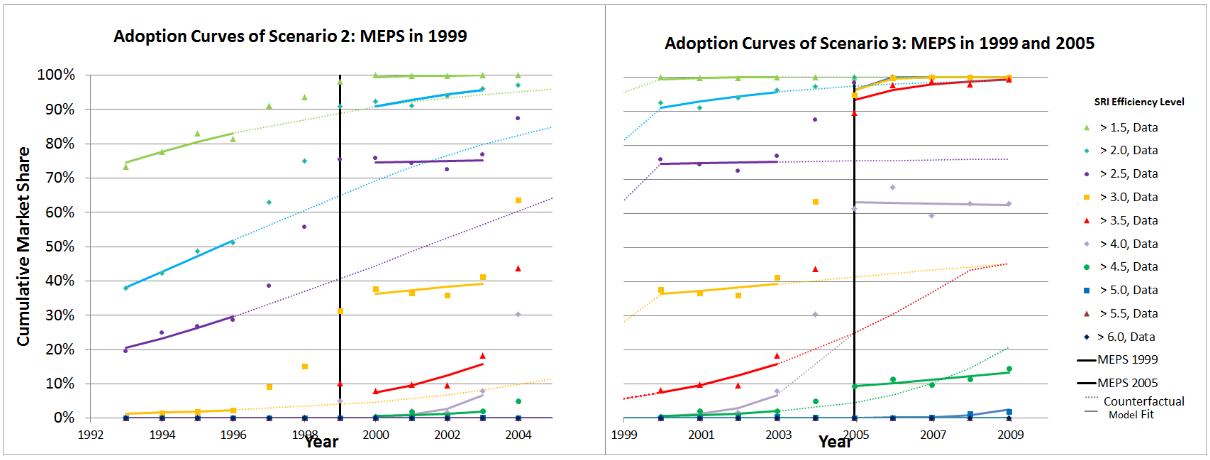

Figure 4: Adoption Curves of Australian Refrigerators for Scenarios 2 and 3

Energy Efficiency Improvement and Energy Savings

The left-hand panel of Figure 5 below illustrates the weighted average of energy consumption based on the market share data, as well as the weighted average calculated from the counterfactuals determined by the model. The right-hand panel illustrates the cumulative annual energy savings. It is important to note that the calculations of the cumulative annual energy savings for Scenario 2 include the impact of the label re-grade in 2000.

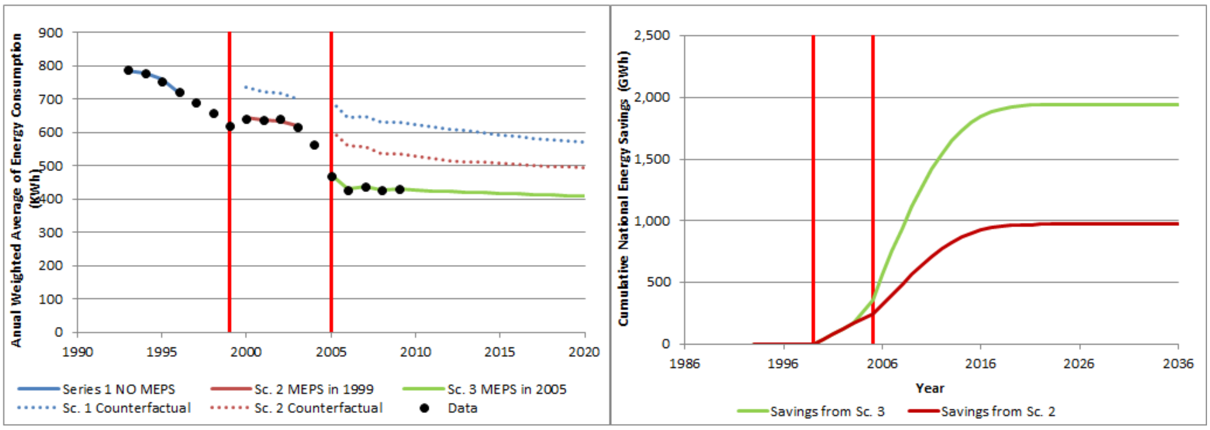

Figure 5: Annual Weighted Average of Energy Consumption (KWh/yr) and Cumulative Annual Energy Savings (GWh)

The black points represent the yearly weighted averages of energy consumption, calculated from data points provided by the market analysis, while the solid line is the weighted average of energy determined from the modeled S-curves. The dotted lines are counterfactuals extrapolated from the S-curves: the dotted blue line represents the counterfactual of Scenario 1 (no MEPS in 1999 or 2005) and the dotted red line represents the counterfactual of the MEPS introduced in both 1999 (Scenario 2). The solid green line represents the model fit for Scenario 3, which lines up nicely with the data points.

The energy savings from Scenarios 2 and 3 can be evaluated by looking at the area between both the dotted blue line and the solid red line, and between the solid green line and the dotted red line respectively.

As demonstrated by the right-hand panel of Figure 5 above, the MEPS in 1999 produces significant energy savings, however the savings are not as significant as when combined with the MEPS in 2005.While the 1999 MEPS served to phase in high-efficiency appliances and phase out low-efficiency appliances, it appears that the 2005 MEPS served to significantly accelerate the market and further increase energy savings.

Conclusion

The approach set out in this paper provides an innovative methodology for more objective evaluation of energy savings from different program measures implemented at different points in time. The starting point of the analysis was to apply a consistent diffusion curve to each efficiency category within each policy in order to measure a critical parameter that characterizes the effectiveness of the program. In particular, the construction of a policy “counterfactual” using this method represents an improvement over more aggregate methods. There are two reasons for this. First, separate modeling of each efficiency category using standard diffusion curves captures saturation effects more accurately than extrapolation of market averages. Second, the statistical methods outlined here allow for quantification of the model’s reliability through estimation of the uncertainty on fit parameters[9].

The case of the Australian refrigerator efficiency program demonstrates both the advantages of this method, and its limitations. First of all, the interplay between the two types of programs that co-exist in the Australian program produces a complex picture. As can be seen in the figures above, MEPS cannot be seen as having simply accelerated the rate of improvement of efficiency in the Australian market. While MEPS were successful in raising the average efficiency of the market, once implemented they seem to have led to a period of relative stagnation in which the market shows little improvement until the announcement of the next round of MEPS. This is hardly surprising, as implementation of stringent MEPS will reduce opportunities for additional energy saving design

[9]The statistical analysis allows for quantification of uncertainties using error propagation, which will be considered in future studies.

improvements by manufacturers for some time after MEPS, especially where all models have to be fully re-engineered just to meet the new mandatory requirements.

Interestingly, a dynamic that can clearly be seen is that both MEPS implemented in during the period of study seemed to have induced the introduction of new higher-efficiency products into the market. It should be noted, however, that this effect is more prominent in the case of the 1999 MEPS, and may be conflated with the effects of the 2000 rescaling of the label categories, which for practical reasons have been folded into the savings estimates for Scenario 2 (MEPS 1999).

Despite the analytical rigor offered by this methodology, therefore, some understanding of the context of program implementation and the practical timetable of market reactions needs to be taken into consideration. For example, in the face of large energy reductions from new MEPS regulations, manufacturers have to start introducing new compliant models well ahead of the final implementation date. So some judgment is still required regarding the effective points where the policy measure started to have an impact. However, with further investigations and experience, it should be possible to provide common sense guidelines to allow the approach to be applied in a coherent manner in appropriate circumstances in a range of countries and for a range of different appliance types.

In conclusion, from this example, we judge that the analysis we applied provides a useful framework for policy analysis, but should be used with care. The two most important lessons from the Australian refrigerator case:

- MEPS Announcements dates (in contrast with MEPS implementation dates) have an important early effect on transformation of the market;
- The time coincidence of the 1999 MEPS and the rescaling of the labels makes the separate impacts of these two policy shifts difficult to disentangle.

The method set out in this paper can already be shown to have provided some insights into these questions. Breaking up the market into labeling categories clearly shows three effects that drive market transformation (1) elimination of low-efficiency units as a response to MEPS (2) gradual increase in market share of high-efficiency products as a result of labels and (3) manufacturer response to announcement of MEPS. While these effects were known by researchers and practitioners of efficiency programs, the methodology described here provides a robust and consistent way to describe these effects and, ultimately, design more effective programs.

A related point is that where a product may be subject to a large number of program changes at relatively short intervals over a long period, it is unlikely that there will be sufficient time to establish reliable values for the diffusion parameters required for this type of analysis. The other observation is that to apply this methodology, some form of categorical system of energy labeling needs to be in place. Ideally this should be visible to purchasers and should provide a relatively neutral and objective assessment of the relative efficiency of different product types.

References

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