Market Transformation: What is Happening and Why?

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ABSTRACT

In recent years considerable attention has been placed on market transformation for energy using technologies. A number of studies have pursued such issues as the definition of market transformation, the nature and objectives of market transformation programs and indicators of market transformation. The purpose of this paper is to present and apply an econometric approach to the evaluation of market transformation programs which focuses on the estimation of program impacts on prices and quantities of energy efficient products. The empirical work focuses on two case studies of energy efficient lighting in Thailand. These studies used annual time series information on sales and prices of lighting products in Thailand. There are three main conclusions. First, the Compact Fluorescent Lamp Program had a significant impact on the sales and prices of compact fluorescent lamps in Thailand for the program period examined. Second, the Energy Efficient Fluorescent Tube Program had a significant impact on sales and prices of T8 tubes. Third, modeling the program response of sales and prices of lighting products in Thailand using regression analysis was generally successful in that the regressions have good explanatory power and the majority of coefficients have plausible and statistically significant test-statistics. Fourth, further research to refine and apply the econometric approach to the analysis of market transformation programs appears warranted.

Introduction

In recent years considerable attention has been placed on market transformation for energy using technologies. A number of studies have pursued such issues as the definition of market transformation, the nature and objectives of market transformation programs and indicators of market transformation. Krause 1996, for example, describes market transformation as policies that reduce the energy-use related environmental externalities by means other than price increases. Duke and Kammen 1999, conversely, define market transformation as policies that increase short-term demand in order to commercialize new clean energy technologies.

A major practical difference between analysis of market transformation programs and analysis of demand side management programs is the scope of the analysis. While a market transformation program analysis considers both the demand and supply sides of a market, DSM program analysis typically ignores producer responses and price effects, focusing instead on consumer responses to incentive or information programs. In other words, program induced demand shifts are assumed to have no impact on product prices. This approach to DSM analysis makes some sense in contexts where program impacts are small compared to the size of the market and has the advantage of significantly simplifying the analysis. But it makes less sense where the intent of a program is to transform a market, rather than merely capture short-term energy savings.

The purpose of this paper is to present and apply an econometric approach to the evaluation of market transformation programs which focuses on the estimation of program impacts on prices and quantities of energy efficient products. An outline of the paper is as follows. The next section reviews the econometric literature on market transformation evaluation. The following section provides the proposed market transformation evaluation framework. This is followed by a brief review of energy efficient policy in Thailand and analysis of two case studies of energy efficiency programs in Thailand. The final section offers some concluding comments.

Literature Review

Three main types of econometric studies provide quantitative information on market transformation: (a) learning or experience curve studies; (b) discrete choice theory studies; and (c) demand and supply studies. We briefly discuss each concept and mention studies that apply an econometric approach using at least five years of market data on prices or quantities for efficient products.

Learning or experience curves model the fact that for many products, unit product costs decrease with increased experience. The original concept was that production experience leads to increases in worker skills and lower production costs in a smooth and regular manner. The Boston Consulting Group broadened the concept from worker related learning to efficiency improvements accruing to all factors of production (Boston Consulting Group 1972). In an influential paper, Bass 1990 integrates the concepts of experience curves and diffusion rates and develops key elements of a market transformation approach. Several studies have estimated learning curves for energy using technologies, where the learning rate is the reduction in cost for a doubling of output. Akisawa 2000 estimated learning curves for air conditioner heat pumps using Japanese data, and he found a learning rate of some 10%, in other words, for the period examined a doubling of production of air conditioner heat pumps reduces unit costs by 10%. Iwafune 2000 applied learning curve modelling to compact fluorescent lamps and found a learning rate of 16%. Lipman and Sperling 1999 considered learning rates for laser diodes and found a learning rate of 23%. Taken together these studies have significant implications for market transformation programs, because they suggest that efforts to increase market sales and encourage early adoption of efficient technologies can have big payoffs in terms of cost reductions and consumer welfare improvements.

Discrete choice theory studies focus on the determinants of consumer behaviour, with a view to determining the net impact of program activities. They are thus an appropriate means of estimating program attribution rates, if detailed suitable data is available or can be collected. Several recent studies use discrete choice methods to analyze energy efficiency programs. Hassett and Metcalf 1995 investigated the impact of a US Federal Government tax credit program on energy efficiency investments. They concluded that a ten-percentage point reduction in tax price for energy investments increased the probability of investment by 24 percent. In two related papers on energy efficient fuel switching, Tiedemann 1994 and 1995 investigated the impact of an electricity to natural gas fuel switching program on installation rates of natural gas space heating and natural gas water heating in new residential housing developments. He found that estimated rates of return were in the 15% range after allowing for depreciation and that differential rates of return between owner occupied and rental housing provided evidence of a

split-incentive market failure.

Demand and supply studies examine the impact of market transformation studies on both producers and consumers. These models can readily accommodate learning curve or experience curve effects on the supply side of the model and utility or government incentive or information programs on the demand side of the model. Duke and Kammen 1999 conducted an extensive study of electronic ballasts and found that accounting for feedback between the demand response and production response significantly increases the consumer benefit cost ratio. Horowitz 2001 modelled electronic ballast price and quantity responses for the pre-Green Lights (control) and post-Green Lights (treatment) periods and found that national market transformation efforts were more cost effective than local programs. Jaffe and Stavins 1995 examined the determinants of ceiling, wall and floor insulation levels and concluded that insulation levels in new residential housing appropriately reflect energy prices. Newell, Jaffe and Stavins 1999 looked at room air conditioners, central air conditioners and water heaters and found that higher energy prices are a partial determinant of adoption of efficient appliances. Nanduri, Bilodeau and Tiedemann 2002 used demand and supply modelling to examine separately the markets for refrigerators, freezers, clothes washers, clothes dryers, dishwashers, and electric ranges and to estimate gross energy savings by appliance type and year. They found significant producer and consumer impacts caused by energy efficiency labelling.

Market Transformation Model

To understand the effects of a market transformation program, a clear and well-defined conceptual model of the market is needed. Figure 1 represents the usual demand and supply model for an appliance in a single country, where the quantity of the appliance is measured from the origin on the horizontal axis and the per unit price is measured from the origin on the vertical axis. In this model, the quantity demanded as a function of price is given by the demand curve D for every possible price, and the quantity supplied as a function of price is given by the supply curve S.

The demand curve D is assumed to slope downward from the left in the usual manner. This means that at lower prices, higher quantities of the appliance are demanded. Since the majority of energy efficient lamps sold in Thailand are imported, the supply curve S is assumed to be horizontal (perfectly elastic) at the price P. P is the import price at the port of entry plus tariffs plus domestic distribution costs including profit margins minus subsidies. In equilibrium the quantity demanded equals the quantity supplied at the price P.

Note that shifts in the demand and supply curves can be interpreted in terms of the domestic market transformation programs. The shift from D_1 to D_2 represents the demand-pull aspects of the domestic program. This includes all activities that operate primarily by increasing the demand for energy efficient lighting such as advertising, promotions, mall displays and school training programs. The shift from S_1 to S_2 represents the technology push aspects of the domestic program. This includes all activities that operate primarily by increasing the supply of energy efficient lighting products such as labelling and product testing and retail subsidies.

FIGURE 1

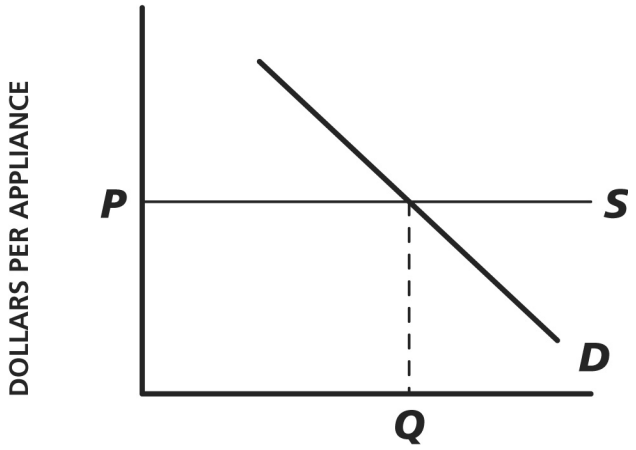
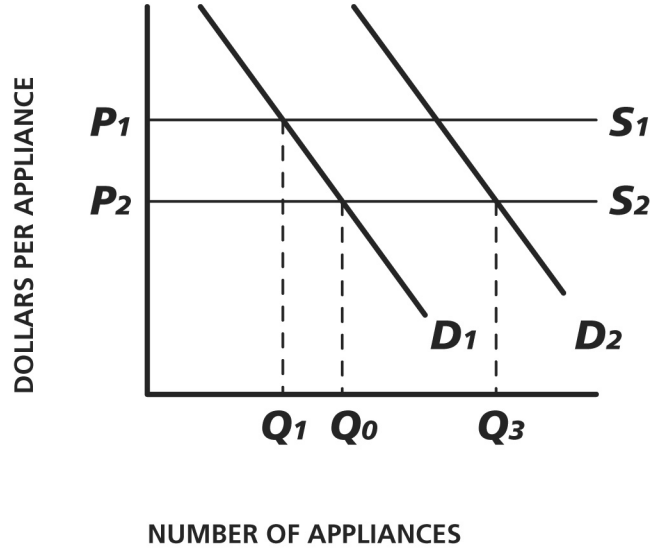


FIGURE 2



Program Background

Over the past twenty years, Thailand has experienced significant increases in electricity consumption and peak demand. These increases in electricity consumption and demand are due to such factors as increased industrialisation of the economy with higher motor and process loads, growth in commercial floor stock with higher lighting and air conditioning loads, and higher incomes that have led to enhanced household electricity use. By the early 1990s, some components of the electricity generation, transmission and distribution system were approaching capacity constraints.

In 1991, the Government of Thailand became the first developing country to adopt a national DSM plan. The objectives of the program were to stimulate local manufacturers and importers to produce and import energy-efficient and energy-saving appliances, provide

consumers with information and incentives to purchase more efficient appliances, and support energy efficient and load management technologies. The Government of Thailand subsequently implemented some eighteen energy conservation programs in the residential, commercial, government and industrial sectors. We apply the market transformation model to two of these programs: The Energy Efficient Fluorescent Tube Program and the Compact Fluorescent Lamp Program.

Compact Fluorescent Lamps

Program description. The overall objective of the Compact Fluorescent Lamp Program was to transform the lamp market from standard efficiency GLS lamps to high efficiency compact fluorescent lamps. The main barriers to achieving market transformation were high first costs and informational and behavioural constraints. At program launch in September 1996, typical prices were about 350-450 baht for 11 Watt to 13 Watt CFLs and 10-20 baht for 40W to 60W GLS lamps. To overcome high first costs, bulk purchasing of CFLs was used with the savings passed on to consumers. EGAT purchased the CFLs in bulk from importers and provided them for sale primarily through Seven Eleven stores. To overcome informational and behavioural barriers, advertising and promotions were used to make customers aware of the benefits of compact fluorescent tubes (Agra Monenco and BC Hydro International 2000).

Sales effects. In Thailand, integrated CFLs compete mainly with GLS (incandescent) lamps, so it is reasonable to examine jointly the impact of the program on the purchases of integrated CFLs and GLS lamps. We apply the regression discontinuity model in which the outcome variable is modelled as a function of key drivers plus a dummy variable that represents the period of the program. The coefficient on the program variable dummy then estimates the impact of the program on the outcome variables for the years 1996 and 1997. With only six years of annual data, it is necessary to apply a very simple framework in which the outcome is a function of a time trend (Year) and the program dummy variable (Program). Also, note that because quarterly data was not available, 1996 was counted a program year even though the program was available for the last few months of that year.

In Table 1, the outcome variables are the quantities of CFLs sold and the quantities of GLS lamps sold in thousands of units over the period 1992-1997. The ordinary least squares estimate for program impact on CFL sales has an adequate fit with an adjusted R-squared of 0.95 and coefficients with statistically significant values with the expected signs. The estimated impact of the program is an average increase in sales of 232,000 CFLs per year for each of the two years of the program included in the analysis. The ordinary least squares estimate for program impact on GLS sales has an adequate fit with an adjusted R-squared of 0.45 but coefficients that are not statistically significant at the 95% confidence level. The program has no measurable impact on sales of GLS lamps.

The maximum likelihood estimate for program impact on CFL sales has coefficients with the statistically significant values with the expected signs. The estimated impact of the program is an average increase in sales of 281,000 CFLs per year for each of the two years of the program included in the analysis. The maximum likelihood estimate for program impact on

GLS sales again has coefficients which are not statistically significant at the 95% confidence level, so that again the program has no measurable impact on GLS sales.

Table 1. Thailand: Quantity Regressions for Lamps (outcomes are sales in thousands)

	CFL (ordinary least squares)	CFL (maximum likelihood)	GLS (ordinary least squares)	GLS (maximum likelihood)
Constant	943 (92) [10.2]	984 (56) [17.6]	28125 (2431) [11.6]	26584 (1339) [19.9]
Year	123 (33) [3.67]	104 (21) [4.97]	566 (881) [0.64]	1243 (500) [2.49]
Program	232 (121) [1.92]	281 (75) [3.75]	881 (3190) [0.28]	-917 (1783) [-0.52]
Adjusted R-squared	0.95	-	0.45	-
Log-likelihood	-	-31.3	-	-50.6
Durbin-Watson	2.16	3.13	2.08	3.14
Estimated Autocorrelation	-0.08	-0.56	-0.04	-0.57

Note: Standard errors in parentheses and t-statistics in square brackets.

Price effects. In Table 2, the outcome variables are the prices of CFLs and the prices of GLS lamps in baht for 1992-1997. The ordinary least squares estimate for program impact on CFL prices has an adequate fit with an adjusted R-squared of 0.99 and coefficients with statistically significant values with the expected signs. The estimated impact of the program is a decrease in price of 164 baht per lamp. The ordinary least squares estimate for program impact on GLS prices also has an adequate fit with an adjusted R-squared of 0.32 and coefficients which are statistically significant and have the expected signs. The estimated impact of the program is a decrease in price of 2.95 baht per lamp.

The maximum likelihood estimate for program impact on CFL prices has coefficients with statistically significant values with the expected signs. The estimated impact of the program is a decrease in price of 159 baht per lamp. The maximum likelihood estimate for program impact on GLS prices also has coefficients that are statistically significant and have the expected signs. The estimated impact of the program is a decrease in price of 3.25 baht per lamp.

Fluorescent Tubes

Program description. The overall objective of the Energy Efficient Fluorescent Tube Program was to transform the fluorescent tube market from standard efficiency T10-12 fluorescent tubes to high efficiency T8 tubes. The main barriers to achieving market transformation were

informational and behavioural in nature. Incremental cost was not viewed as a major barrier to market transformation, since production costs for T8 and T10-12 tubes were similar, around 40 baht for T8 tubes and 36 baht for T10-12 tubes. To overcome informational and behavioural barriers, a comprehensive advertising and promotional campaign was put in place to make customers aware of the benefits of T8 fluorescent tubes. The other key components of the program were a voluntary agreement with five major Thai manufacturers to switch production for domestic sales to thin fluorescent tubes by October 1995 and a direct retrofit program for city halls and schools (Agra Monenco and BC Hydro International 2000, Sulyma et al. 2000).

Table 2. Price Regressions for Lamps (outcomes are prices in baht)

	CFL (ordinary least squares)	CFL (maximum likelihood)	GLS (ordinary least squares)	GLS (maximum likelihood)
Constant	339 (7.9) [42.7]	342 (3.6) [95.1]	11 (1.1) [9.60]	11 (1.0) [10.3]
Year	15 (2.9) [5.06]	13 (1.3) [9.92]	0.82 (0.41) [1.98]	0.96 (0.39) [2.49]
Program	-164 (10) [-15.7]	-159 (5.8) [-33.1]	-2.95 (1.50) [-1.97]	-3.25 (1.41) [-2.30]
Adjusted R-squared	0.99	-	0.32	-
Log-likelihood	-	-14.9	-	-6.1
Durbin-Watson	3.31	3.14	2.14	2.38
Estimated Autocorrelation	-0.067	-0.57	0.04	-0.19

Note: Standard errors in parentheses and t-statistics in square brackets.

Sales effects. In Thailand the main competitor for the standard T10 and T12 fluorescent tubes in the early 1990s was the energy efficient T8 fluorescent tube. Phillips was the first firm to start production of T8 fluorescent tubes in Thailand, with their domestic production beginning in 1991. By 1999, more than 95% of fluorescent tube sales in Thailand were energy efficient tubes (AGRA Monenco Inc. and BC Hydro International Ltd. (2000). Since at program launch, energy efficient fluorescent tubes competed mainly with standard fluorescent tubes, it is again reasonable to examine jointly the impact of the program on the purchases of energy efficient T8 and standard efficiency T10 and T12 tubes. As for CFLs, the regression discontinuity model is applied in which the outcome variable is modelled as a function of key drivers plus a dummy variable that represents the period of the program examined here. The coefficient on the program variable dummy then estimates the impact of the program on the outcome variables for the program years 1995, 1996 and 1997.

In Table 3, the outcome variables are the quantities of T8 and T10-12 tubes sold in thousands of units over the period 1992-1997. The ordinary least squares estimate for program

impact on T8 sales has an adequate fit with an adjusted R-squared of 0.96 and coefficients with statistically significant values with the expected signs. The estimated impact of the program is an average increase in sales of 1,750,000 T8s per year for each of the three years of the program included in the analysis. The ordinary least squares estimate for program impact on T10-12 sales has an adequate fit with an adjusted R-squared of 0.89 and coefficients that are statistically significant at the 95% confidence level. The estimated impact of the program is a reduction of sales of T10-12 tubes of 3,890,000 tubes for each of the three years of the program.

The maximum likelihood estimate for program impact on T8 sales has coefficients with the statistically significant values with the expected signs. The estimated impact of the program is an average increase in sales of 2,254,000 T8 tubes per year for each of the three years of the program included in the analysis. The maximum likelihood estimate for program impact on T10-12 sales again has coefficients which are statistically significant at the 95% confidence level, with a reduction in sales of 3,881,000 units per year for each for each three of the three years of the program.

Table 3. Thailand: Quantity Regressions for Tubes (outcomes are sales in thousands)

	T8 (ordinary least squares)	T8 (maximum likelihood)	T10-12 (ordinary least squares)	T10-12 (maximum likelihood)
Constant	36500 (1000) [36.5]	36727 (1070) [34.3]	5549 (453) [12.2]	5546 (455) [12.2]
Year	1750 (433) [4.04]	1742 (356) [4.89]	726 (197) [-3.64]	724 (195) [3.72]
Program	2250 (1479) [1.52]	2254 (1137) [1.98]	-3890 (671) [-5.80]	-3881 (665) [-5.84]
Adjusted R-squared	0.96	-	0.89	-
Log-likelihood	-	-46.4	-	-42.3
Durbin-Watson	1.00	0.84	1.76	1.95
Estimated Autocorrelation	0.50	0.58	0.12	0.03

Note: Standard errors in parentheses and t-statistics in square brackets.

Price effects. In Table 4, the outcome variables are the prices of T8 and the prices of T10-12 tubes in baht for 1992-1997. The ordinary least squares estimate for program impact on T8 prices has an adequate fit with an adjusted R-squared of 0.96 and coefficients with statistically significant values with the expected signs. The estimated impact of the program is a decrease in price of 0.75 baht per lamp. The ordinary least squares estimate for program impact on T10-12 prices also has an adequate fit with an adjusted R-squared of 0.97 and coefficients which are statistically significant and have the expected signs. The estimated impact of the program is a

decrease in price of 0.75 baht per lamp.

The maximum likelihood estimate for program impact on T8 prices has coefficients with statistically significant values with the expected signs. The estimated impact of the program is a decrease in price of 0.74 baht per lamp. The maximum likelihood estimate for program impact on T10-12 prices also has coefficients that are statistically significant and have the expected signs. The estimated impact of the program is a decrease in price of 0.70 baht per lamp.

Table 4. Price Regressions for Tubes (outcomes are prices in baht)

	T8 (ordinary least squares)	T8 (maximum likelihood)	T10-12 (ordinary least squares)	T10-12 (maximum likelihood)
Constant	48 (0.69) [68.9]	48 (0.65) [73.1]	44 (0.69) [63.7]	44 (0.53) [83.2]
Year	-0.75 (0.30) [-2.50]	-0.74 (0.30) [-2.44]	-0.75 (0.30) [-2.49]	-0.70 (0.25) [-2.78]
Program	-3.42 (1.03) [-3.32]	-3.49 (1.02) [-3.40]	-3.75 (1.02) [-3.65]	-4.09 (0.83) [-4.93]
Adjusted R-squared	0.96	-	0.97	-
Log-likelihood	-	-3.2	-	-2.2
Durbin-Watson	2.56	2.0	2.77	2.15
Estimated Autocorrelation	-0.28	-0.25	-0.38	-0.08

Note: Standard errors in parentheses and t-statistics in square brackets.

Summary and Conclusions

The purpose of this paper is to present and apply an econometric approach to the evaluation of market transformation programs which focuses on the estimation of program impacts on prices and quantities of energy efficient products. The empirical work focuses on two case studies of energy efficient lighting in Thailand. These studies used annual time series information on sales and prices of lighting products in Thailand.

There are four main conclusions. First, the Compact Fluorescent Lamp Program had a significant impact on the sales and prices of compact fluorescent lamps in Thailand for the program period examined. The impact on the alternative GLS lamps was somewhat mixed with no evidence of a reduction in GLS sales, although prices of GLS lamps declined as expected. Second, the Energy Efficient Fluorescent Tube Program had a significant impact on sales and prices of T8 tubes. The sales and prices of alternative T10-12 tubes also declined as expected. Third, modeling the program response of sales and prices of lighting products in Thailand using regression analysis was generally successful. The regressions have good explanatory power and

the majority of coefficients have plausible and statistically significant test-statistics. Fourth, applying this approach requires fairly detailed and accurate information on sales of efficient products both before and during the program period. In particular, data for several pre-program periods is needed to allow robust estimation of demand and supply curve shifts due to the program. Further research to refine and apply the econometric approach appears warranted.

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