Incremental distribution chain costs and markups for energy efficient consumer products

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1. SYNOPSIS

We estimate the markup on incremental appliance (efficiency) costs in retail and wholesale businesses. Incremental markup estimates are 15% to 45% lower than average markups.

2. ABSTRACT

In analysing demand-side energy efficiency policy it is often necessary to evaluate the cost of incremental energy efficiency improvements for the consumer. In an engineering approach this is done by first estimating the increased production cost of higher efficiency products and then using the production cost to estimate retail cost. Approximately one half of the cost of consumer products and appliances arises from the cost of sales and distribution rather than the cost of production. Therefore an analysis of the incremental costs of efficiency improvements in consumer products requires an accurate evaluation of the incremental costs of distribution and sales. We perform both statistical and financial analyses of the retail and wholesale industry to improve the accuracy of incremental distribution chain cost estimates. Our results show that a simple-minded approach of applying a fixed markup to incremental production costs to obtain the costs to the consumer over-estimates the incremental cost of efficient products by as much as 45%. This study shows that incremental distribution chain costs for appliances are significantly lower than the average distribution costs.

3. INTRODUCTION

Consumer-oriented policy analysis of optimum appliance efficiency standards requires an estimate of the marginal cost of appliance efficiency improvements to the consumer. An engineering/economic approach to the setting of energy efficiency standards for appliances involves an engineering analysis that estimates the incremental manufacturing cost for different efficiency design enhancements relative to baseline appliance designs [Turiel *et al.*, 1997]. To estimate the consumer impacts of the increased manufacturing costs, it is necessary to estimate how the marginal cost increase is passed on to the consumer as a higher cost appliance moves through the distribution chain from the manufacturer to the retail dealer or appliance store.

This paper examines the equipment price markups that wholesalers and retailers apply to cover the extra expenses incurred from distributing higher cost, higher efficiency appliances. We apply two different relatively simple methodologies to the calculation of markups on marginal equipment costs. One methodology consists of a statistical fit of a price model to data from the U.S. Economic Census, and the other methodology consists of a financial analysis of retail and wholesale industries to determine the markups required to recover their business investments and expenses.

In the U.S., an evaluation of the costs and benefits of appliance standards is a legal requirement for appliance efficiency regulations. Specifically, U.S. law requires a determination of the economic justification of the efficiency

improvements including the “economic impact of the standard ... on the consumer of the products subject to such a standard” [P.L 94-163 as amended by P.L. 95-619 and P.L. 100-12].

In 1982, the Department of Energy used “EXPLOR MULTITRADE, a continuously evolving econometric model based on input/output (I/O) analysis [which] was developed by Batelle in the early 1960’s” to calculate how prices propagated through the distribution chain to the consumer [DOE, 1982]. This model calculated prices by assuming that material costs are passed through and then calculating the ‘value added’ per unit of output which was calculated separately. The added value consisted of profit-type income, labour compensation and indirect business taxes.

But since that time the U.S. Department of Energy has generally used average markups for the estimation of consumer costs from manufacturer price. In 1990, the Department of Energy utilised a constant markup of 1.46 for its markup on incremental costs for dishwashers, clothes washers and clothes dryers [DOE, 1990]. In the analysis for the recent clothes washer rule, an average markup of 1.40 was used [DOE, 2000]. Meanwhile for some other analyses (e.g. Florescent Lamp Ballast’s and Water Heaters), retail prices were used directly for estimating consumer impacts. But the direct use of consumer prices is feasible only when the higher efficiency models under consideration are already in the market

Average markups for estimation of consumer cost from manufacturer price are appropriate when one needs a simple, but possibly high estimate of the consumer costs of efficiency and when retail prices are not available directly. For those analyses where a more detailed and precise evaluation of the cost is needed and the products are not yet in the market, it may be important to evaluate the markups on incremental manufacturer prices rather than the average markup on total manufacturer prices. These incremental markups may provide a more accurate forecast of the consumer price of future high-efficiency models than an average markup that may include distribution cost components that do not scale with manufacturer price.

When the markup is calculated by dividing the consumer price by manufacturer price, we call this the ‘average markup’ method. The ‘average markup’ method uses publicly available corporate and industry data (such as data from the U.S. Economic Census) and assumes that gross margin determines the effective markup on a company’s costs of sales. It includes all corporate overhead costs: sales, general and administration, research and development, interest expenses, depreciation and taxes, and profit. The ratio of total business to direct costs is used to determine the markup on direct costs. As many expenses are included in the gross margin, the markups obtained by using the average markup method are significantly larger than one. In the Central Air Conditioner and Heat Pump Advanced Notice of Proposed Rulemaking (ANOPR) values of 1.37 and 1.55 were obtained for distributor (wholesaler) and dealer (retailer) markups respectively [DOE, 1999, (1)].

Actual distributor chain markups on incremental costs of goods lies between the value obtained from the average markup factor and one. If none of the distribution chain costs scale with the unit cost of sales, then the markup is one, while if all of the distribution chain costs scale with the unit cost of sales then it is equal to the average markup. The purpose of this paper is to increase the precision of distributor chain markup estimates through the analysis and evaluation of economic and financial data from wholesale and retail industry businesses. This will allow us to estimate which fraction of distribution chain costs scale with the unit cost of sales and to estimate the distribution chain markup on incremental unit costs.

Methods

We describe two different approaches for determining the markups on marginal costs: the firsts uses data provided by the U.S. Bureau of Census to make a statistical, economic determination of the markup, while the second uses a financial analysis of publicly traded retail companies.

The statistical determination of the markup looks at cost and revenue data for both wholesale and retail industries and fits a cost function to the data. This way we find empirically the fixed, labour, and equipment costs of distribution and their associated overheads costs and profits. Typically when the efficiency of an appliance is increased, there is an increase in the cost of manufacture, but otherwise the appliance is very much the same. This implies that the sales price will scale with the equipment overhead costs, and not the labour overhead costs. The

statistical method finds empirically the scaling factor for labour and equipment costs (cost of goods) by comparing data across industries that have different labour intensities of distribution.

In contrast the financial method of estimating incremental markups on equipment evaluates the incremental markup from the perspective of an investor. An investor will demand a given return on equity (15% to 30%) from their investment. For wholesale and retail distribution industries, most equity is tied up in inventory and bills receivable. We therefore assume that increases in equipment cost will cause a proportional increase in inventory and bills receivable and that the investor will want returns on the added investment. Assuming that return on investment is the primary purpose of the equipment markup we calculate the associated markup on equipment and obtain an alternative incremental markup on equipment costs.

Statistical analysis

In the statistical analysis, we fit a linear production function to economic data for the wholesale and retail distribution industries. In this analysis, the average markup approach corresponds to particular assumptions about the form of the distribution chain production function. A statistical analysis of U.S. Economic Census data allows us to test the assumptions of the current markup approach vis-a-vis less constrained economic production functions for the distribution industry.

A simple linear production function for the retail and wholesale distribution industries has the following form:

$$P_{out} = a + b* P_{in} + c* W$$

where P_{out} is the sales, P_{in} is the cost of sales, W is the labour expenses of the business, and a, b, and c are constants determined by the fit with the data. The 'average markup' method assume that $a=c=0$ and calculates b as

$$b = (P_{out} / P_{in})$$

The fit for the linear production function was performed with a simple least-squares regression utility in a spreadsheet. Once the data was collected the regression was simple to perform. We cross-checked our results by performing other fits to state-by-state data for selected appliance and equipment distribution industries.

Financial analysis

The financial analysis method calculates the incremental markup on the cost of sales that is necessary to maintain the existing return on equity that is enjoyed by the stockholders of specific, publicly traded U.S. retail companies. To perform this analysis we used available financial from publicly traded retail companies. We used the "net present value rule" to determine the markup that retail and wholesale investors would require to compensate for increased cost of sales. This rule states that a business can accept investments that have positive net present values [Richard A. Bradley and Stewart C. Myers, 1996, (2)]. And when the cost of goods increases, extra investment is needed to pay for inventory and the money invested in accounts receivable. In other words, we calculated the markup retailers had to apply so that the investment they make for the sale of higher efficiency machines will have a null net present value, which means that they will recover their investment. The net present value on additional expenses is calculated as follows:

$$NPV = C_1 + C/r$$

Where C_1 is the money invested the first year to start the production of high efficient units, C_1 is usually negative. C/r is a perpetuity that produces a cash flow of C in each following year: this is the net revenue earned by selling more expensive machines. The rate of return is r, which we assumed to be the sum of the long-term growth rate of the company and the profit margin. As long as the increase in capital investment is only necessary for the first year, we have:

$$C_1 = \_\_Sales) - \_\_Cost\ of\ Goods) - \_\_Capital\ Investment)$$
$$C = \_\_Sales) - \_\_Cost\ of\ Goods)$$

A new efficiency standard will generally result in some increase in direct equipment costs, and we assume that capital investment will scale proportional to the increase in equipment price. We assumed that the capital investment was equal to the total current assets of the company. Then, the increases in the different costs will be as follows:

$\Delta(\text{Costs of Goods}) = (\text{Cost of Goods})_0 * y$
$\Delta(\text{Capital Investment}) = (\text{Total Current Assets})_0 * y$
$\Delta(\text{Sales}) = (\text{Cost of Goods})_0 * y * z$

Where *y* is the increase factor on equipment cost due to the standard and *z* is the markup factor to apply so that the net present value equal zero. The subscript *0* represents the year of the last annual report available for each company.

Then, by setting the net present value to zero, we determine the markup factor z:

$$z = [\Delta(\text{Costs of Goods})*(1+r) + \Delta(\text{Capital Investment})*r] / [\Delta(\text{Costs of Goods})*(1+r)]$$

Note that each of these terms is proportional to y, so the markup factor will not depend on the increase factor.

Results

In general, we find that the markups on marginal equipment costs derived from statistical and financial analysis are significantly lower than those determined from the average markup analysis.

Statistical analysis

The statistical analysis was performed for wholesalers and retailers. For the statistical analyses we perform a cross-industry correlation analysis of both the wholesale and retail industries.

- *Wholesaler markups*

  We applied a cross-industry regression analysis for both the durable and non-durable goods wholesalers (1992 Economic Census). The Economic Census provides total cost of sales, payroll, and sales for different categories of wholesale industries. We fit the linear production function ($P_{out} = a + b* P_{in} + c* W$) to the data across the different components of the industry which have different labour intensities. This provides two estimates for the marginal markups on labour and cost of sales. The results with along with the 95% confidence interval for the regression are presented in Table 1:

Table 1. Regression results for wholesale incremental markup factors

	Markup on equipment (b)			Markup on labour (c)		
	Min	**Mean**	**Max**	**Min**	**Mean**	**Max**
Durables wholesalers	1.06	1.11	1.17	1.20	1.60	2.02
Nondurables wholesalers	0.96	1.01	1.06	1.54	2.21	2.87

  Note that the markup on incremental cost of sales is estimated at 1.11 for durable goods and 1.01 for non-durable goods. This should be compared to the average markup results that are calculated as 1.33 and 1.20 respectively.

  The incremental markup on cost of sales is less than the average markup because many business expenses, like the Selling, General and Administrative (SG & A) expenses, do not increase with unit equipment cost increases (as assumed in the average markup model). Since the price of labour is determined in a market that is largely independent of equipment manufacture markets, we believe that a disaggregated markup model with distinct

markup factors for incremental labour and equipment costs is a more accurate description of how increased costs of sales propagate to the consumer.

- *Retailer markups*

  The U.S. Census Bureau (1992 Economic Census, retailers) provides the economic data of revenues and costs for different retail industries for the U.S. in 1992. We perform the same cross-industry regression analysis to determine the markup coefficients for costs of sales and payroll expenses. The results of this analysis are summarised in Table 2:

Table 2. Regression results for retail incremental markup factors

Markup on equipment (b)			**Markup on labour (c)**		
Min	Mean	Max	Min	Mean	Max
0.98	1.15	1.33	1.19	2.13	3.03

For the same data, the average markup analysis gives an average aggregate markup of 1.59. Similar to the analysis for the wholesale industry we find that the markup on incremental cost of sales is much lower than the aggregate markup obtained from the average markup method.

Note that for products that go through two stages in the distribution change, the difference between the combined average markup and the combined incremental markup is even greater. For the average markup method, for durable goods we obtain a combined markup of 1.33 * 1.59 = 2.11. In contrast if we use markups on incremental costs we obtain a combined markup of: 1.11 * 1.15 = 1.28. The incremental markup calculation results in an incremental consumer price estimate that is 40% lower than the estimate obtained from average markups.

Financial analysis

The financial analysis was performed for appliance retail companies. We used the data provided on their annual balance sheet and annual income statement. Table 4 is an extract of those data for several companies.

As a new efficiency standard will result in an increase in equipment cost, we wish to know how retail companies will pass those cost increases to the consumer. In general, “economic efficiency criteria requires that prices should be equal to marginal cost” [Gunter Schramm, 1991, (3)]. Therefore, using the available financial data, we forecasted the markup on equipment price that retailers would apply to cover extra expenses and investment and to make the profit they are seeking. Studying the financial data, we tried to develop reasonable assumptions about business behaviour. We calculated the rate of return as the sum of the forecasted long-term growth and profit margin. The possible investment was assumed to be equal to the total current. Considering that the increase in equipment cost would be y = 10%, we used the net present value rule to determine the markup on equipment costs. We obtained the following results:

Table 3. Financial analysis results for retail incremental markup factors

Company	Capital Increase	Cost of goods Increase	Sales Increase	Rate of Return	Markup on Equipment (z)
Circuit City	294.26	975.18	1027.09	21.42%	1.053
Sears	2866.70	2721.20	3087.51	14.65%	1.135
Lowe's	370.95	1152.50	1230.21	26.50%	1.067
Best Buy	223.85	1010.06	1057.09	26.60%	1.047
Home Depot	639.00	2702.30	2849.46	29.92%	1.054
Good Guys	13.85	69.26	71.12	15.50%	1.027
Lennox	88.76	161.73	172.72	14.13%	1.068
Wal-Mart	2435.60	12966.40	13339.16	18.07%	1.029
Rex Stores	17.94	33.74	37.01	22.30%	1.097
Ultimate Electronics	10.33	26.95	29.18	27.50%	1.083
Whirlpool	317.70	785.20	834.87	18.53%	1.063

Except for the rate of return and the markup on equipment, all values are in million U.S. dollars.

The average retailer markup on cost of goods is 1.07. In contrast, the average ratio of total sales to cost of sales for these businesses is 1.33. This result supports the analysis we made previously. As can be seen in the Table 4, the Selling, General and Administration expenses are a large part of operating expenses. If such expenses to do not scale with the cost of sales then this implies that the markup determined with the average markup method is over-estimated.

4. CONCLUSION

The analyses we provide here estimate wholesaler and retailer markups on incremental cost of sales. We find that assuming that labour expenses and cost of sales make independent contributions to output prices we can calculate the markups on incremental cost of sales using two methods that provide approximately the same results. One method fits production data from the wholesale and retail industries from the U.S. Economic Census to a simple linear input/output model calculates the coefficient for the cost of sales term. The other method is a financial analysis that calculates how much incremental sales must increase given an incremental increase in cost of sales, assuming that the return on equity is preserved. Both methods produce very similar results that imply that the markup on incremental cost of sales ranges from 1.01 to 1.15. This implies that analyses that utilise average markups for estimating consumer incremental costs of efficiency from manufacturer prices may over-estimate the costs of efficiency improvements and result in lost efficiency improvement policy opportunities.

The discrepancy between the markup on incremental costs (i.e. marginal markup) of efficient appliances and the average markup on appliances is to be expected. This is because many of the costs of distribution and sales are fixed or scale with labour costs. And strong competitive pressures in the retail and wholesale distribution industries will generally force retailers and wholesalers to scale sales prices to closely reflect actual costs.

Analyses that use average markups for estimating distribution costs will tend to overestimate markups on incremental costs because markups on labor expenses tend to be much higher than markups on cost of goods. But when there are not the resources to do a detailed markup analysis, it may be reasonable to use average markups as a first approximation.

Table 4. Financial Data for Retail Industries

Company	Circuit City	Sears	Wal-Mart	Home Depot	Good Guys	Best Buy
Total Revenue	12614.4	41071	166809	38434	915.5	12494
Cost of revenue	9751.8	27212	129664	27023	692.6	10100.6
Gross Profit	2862.6	13859	35349	11411	222.9	2393.4
Selling/General/ Administration Expense	2309.6	8418	27040	671	257.4	1854.2
Depreciation/Amortisation	-	848	-	-	-	-
Interest Expense, Net Operating	24.2	1268	1022	-	-	-
Interest Expense (income), Net Operating	24.2	1268	1022	-	-	-
Unusual / Other Expense	-	912	-	6945	-	-
Total Operating Expenses	12085.6	38658	157726	34639	950.1	11954.8
Operating Income	528.8	2413	9083	3795	34.6	539.3
Net Income	197.6	1453	5377	2320	39.3	347.1
Total Inventory	1689.2	5069	19793	5489	110.3	1183.7
Total Current Assets	2942.6	28667	24356	6390	138.5	2238.5
Total Assets	3955.3	36954	70349	17081	226.1	2995.3
Total Current Liabilities	1406.2	13701	25803	3656	73.7	1785
Total Liabilities	1813.2	30115	44515	4740	130.2	1899.4
Total Equity	2142.2	6839	25834	12341	95.9	1096
Total Liability and Shareholders' Equity	3955.3	36954	70349	17081	226.1	2995.3
Total Common Shares Outstanding	203.87	369.1	4457	2304.32	19.64	200.38
Profit Margin	2.60%	3.90%	3.40%	6.10%	-5.00%	2.80%
Long-term Growth Rate	18.82%	10.75%	14.67%	23.82%	20.00%	23.80%

Except the profit margin and the long-term growth all values are in million U.S. dollars.

Extract of the annual income statement and annual balance sheet of different companies for the most recently available annual report as of July 2000.

(Taken from the web site www.marketguide.com)

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