On the Use of Bonus Payments in an Experimental Study of Electricity Demand

Raymond P. H. Fishe; R. Preston McAfee

The Review of Economics and Statistics, Volume 65, Issue 3 (Aug., 1983), 506-511.

Stable URL:
http://links.jstor.org/sici?sici=0034-6535%28198308%2965%3A3%3C506%3AOTUOBP%3E2.0.CO%3B2-G

The reported results suggest that antitrust challenge through litigation has not brought forth any significant structural changes to the affected firms under study during the sample period. This phenomenon may indicate either a low perceived probability of antitrust challenge by the affected firms or the relatively low costs associated with the antitrust litigation (e.g., penalty, court expenses, treble damage claims, et cetera) vis-à-vis the potential benefits from collusive market conduct and/or attempts at oligopoly.[11]

III. Concluding Remarks

The paper has attempted to examine the financial consequences of collusion/antitrust prosecution in established cases of collusive oligopoly. From the financial data of 65 indicted firms and 65 matched control firms, our tests support the hypothesis that antitrust challenge has been effective in the sense that the indicted firms showed restraint in pricing subsequent to the prosecution—the deterrent effect being more robust in the case of inexperienced violators. However, it was also found that other strategic choices of the firms in the sample, such as growth and financial leverage, have not been seriously affected by the antitrust challenge.

[11] On the other hand, as was suggested by Reynolds (1980, pp. 1123–1126), the results can be interpreted to mean that the pre-litigation strategic choices have already reflected the potential antitrust threat and its expected costs. Therefore, any choice of strategies results from the consideration that the action will have the smallest effect on the expected probabilities and costs of antitrust challenge. According to this interpretation, the results in table 1 may reflect the difficulty inherent in the statistical model to detect the effects of an antitrust case. However, in view of our findings that antitrust challenges were perceived asymmetrically by the frequent as well as the first-time violators, this interpretation is not well-supported.

REFERENCES

Asch, Peter, and J. J. Seneca, "Is Collusion Profitable?" this REVIEW 58 (Feb. 1976), 1–12.

Burns, Malcolm R., "The Competitive Effects of Trust-Busting: A Portfolio Analysis," *Journal of Political Economy* 85 (July/Aug. 1977), 717–739.

Clabault, James M., and John F. Burton, Jr., *Sherman Act Indictments, 1955–1965* (New York: Federal Legal Publications, 1966).

Fama, Eugene F., *Foundations of Finance* (New York: Basic Books, Inc., 1976).

Feinberg, Robert M., "Antitrust Enforcement and Subsequent Price Behavior," this REVIEW 62 (Nov. 1980), 609–612.

______, "On Optimal Antitrust Enforcement," *Southern Economic Journal* 49 (Apr. 1982), 1095–1097.

Garbade, Kenneth D., William L. Silber, and Lawrence J. White, "Market Reaction to the Filing of Antitrust Suits: An Aggregate and Cross-Sectional Analysis," this REVIEW 64 (Nov. 1982), 686–691.

Jensen, Michael C., "Capital Markets: Theory and Evidence," *Bell Journal of Economics and Management Science* 3 (Autumn 1972), 357–398.

Lee, Li Way, "Some Models of Antitrust Enforcement," *Southern Economic Journal* 47 (July 1980), 147–155.

Lev, Baruch, "On the Association between Operating Leverage and Risk," *Journal of Financial and Quantitative Analysis* 9 (Sept. 1974), 627–641.

Reynolds, Robert J., "The Economics of Antitrust Enforcement: Theory and Measurement," *Georgetown Law Journal* 68 (1980), 1121–1130.

Scherer, F. M., *Industrial Market Structure and Economic Performance*, 2nd ed. (Chicago: Rand McNally College Publishing Co., 1980).

Telser, Lester G., *Competition, Collusion, and Game Theory* (Chicago: Aldine-Atherton, 1972).

Trade Regulation Reporter, Vol. 4, "New U.S. Antitrust Cases" (Chicago: Commerce Clearing House, 1979).

ON THE USE OF BONUS PAYMENTS IN AN EXPERIMENTAL STUDY OF ELECTRICITY DEMAND

Raymond P. H. Fishe and R. Preston McAfee*

In a recent paper, Raymond Battalio, John Kagel, Robin Winkler, and Richard Winett (1979, hereafter BKWW) report the results of an experimental study of electricity demand. In this study, two randomized groups of households were offered price rebates for reducing their consumption of electricity (relative to a given base level) and a bonus payment as an incentive not to "give up" on energy saving practices. The price rebates were designed to be equivalent to Slutsky compensated price changes and thus, by comparing the consumption responses of these two groups to those of three other "control" groups, BKWW estimate compensated price elasticities of demand for electricity. However, because these two groups were eligible for both a price rebate and a bonus payment, the consumption responses observed cannot be solely attributed to the price rebates. Thus, the elasticities calculated will not be accurate unless the effects of the bonus payments are removed.

Received for publication September 30, 1981. Revision accepted for publication November 10, 1982.

* University of Miami and University of Western Ontario, respectively.

We appreciate the assistance of Raymond Battalio in providing us with the data for this study and the helpful suggestions made by Barry Field and two patient referees. All errors remain our own responsibility.

Our purpose here is twofold. First, we develop the necessary theoretical model of the BKWW experiment and show how the bonus plan fits into the usual utility-maximizing framework. This is important not only to the BKWW experiment, but also to other economic experiments which use bonus payments in their design (e.g., Winett and Nietzel, 1975, and Hill, Ott, Taylor, and Walker, 1983). Our results indicate that the bonus payment acts like an income effect, but cannot be signed a priori even if electricity is a normal good because it is directly related to consumption. Second, we re-estimate the variance-components model used by BKWW taking into consideration the effect of the bonus payment. The results indicate that the bonus plan has a negative impact on consumption, although it is small in absolute magnitude. Also, with respect to the price rebates, we find small compensated price elasticities of demand, although this result is probably due to the short-run nature of the BKWW experiment. Finally, in comparing the two effects, we find that the bonus payments appear to be more significant in reducing electricity consumption during the initial phase of the experiment, but it is not clear if this is a general result because it is not supported in the later phases of the experiment.

I. Theoretical Model

The experiment conducted by BKWW was divided into three periods: a baseline period of two weeks used to determine pre-experimental consumption levels; an initial experimental period of four weeks when the treatments were applied; and a follow-up period of six weeks when some treatments were changed to substantiate initial results. Our analysis here is primarily concerned with the initial experimental period when the households were randomly assigned to different treatments.

The initial experimental period contained five treatment groups, with two of these being eligible for price rebates and bonus payments. The bonus payments in these two groups were given only to households who fell in the top half of their group in terms of percentage reduction in electricity consumption. As such, each household's total monetary compensation was directly related to the median percentage reduction in their group. The median for these groups was not known by any household during the experiment. The only information a household received was a weekly report of their own consumption pattern. Thus, eligibility for the bonus could not be determined during the experiment. In contrast, the amount of the price rebate could easily be calculated using the weekly consumption information.

With this experimental design, the bonus plan is similar to a lottery in the sense that the household either will or will not receive the bonus and this is not known a priori. However, in most lotteries the probability of winning is independent of the household's consumption decision, whereas here it is dependent. To see this let us define

$\beta \equiv$ bonus payment,
$x_0 \equiv$ pre-experimental consumption of electricity (base),
$x \equiv$ consumption of electricity during the experiment, and
$f(x_m) \equiv$ prior density of the group's median (x_m) percentage reduction in electricity usage.

Then, according to the BKWW experimental design, the household's subjective probability of *not* receiving $\beta, \Psi(x)$, is written as

$$\Psi(x) = \int_{-\infty}^{(x-x_0)/x_0} f(x_m)\, dx_m. \tag{1}$$

One can readily see that this is a direct function of electricity consumption during the experiment.

This probability is important because the household will choose x before the outcome of the lottery is known, i.e., before eligibility for the bonus is determined. Thus, the household's utility will be stochastic and some summary measure of utility will be used to determine consumption. We will assume that the household maximizes expected utility to solve the problem posed by this experiment.[1] We may write this problem in the two good case as

$$\text{Max } H(x) = \Psi(x)U\left(x, \frac{M+\gamma-p_1x}{p_2}\right) + (1-\Psi(x))U\left(x, \frac{M+\beta-p_1x}{p_2}\right), \tag{2}$$

where p_1 is the price of electricity (measured in ¢/KWH), p_2 is the price of the second (Hicks' composite) good, M is money income, and γ is the payment when one does not win the bonus (here it is zero).

If we let U^m and U^n represent utility with and without the bonus, respectively, then optimality requires

[1] There are problems with using expected utility in this case because the household must make some pre-lottery consumption decision. Hence, the substitutability axiom of von Neumann-Morgenstern theory will not apply (Spence and Zeckhauser, 1972; Eden, 1980). However, since there is only one random event here this should not be a problem.

Also, this formulation overcomes any question about the endogeneity of the bonus variable in our empirical results. In maximizing expected utility, these households determine consumption of electricity conditional on their prior probability of receiving the bonus. They do not know if they will receive the bonus when they solve this problem. Thus, during the experiment, the bonus is an exogenous variable.

that

$$H'(x) = \Psi(x)\frac{\partial U^m}{\partial x} + (1 - \Psi(x))\frac{\partial U^m}{\partial x} + \Psi'(x)(U^n - U^m) = 0. \quad (3)$$

This is an interesting condition because it deviates from the usual expected utility problem by the last term on the right-hand-side. Under suitable regularity conditions this term will be negative, and thus one can show that $x^{**} < x^*$, where x^{**} is the solution to (3) and x^* solves (2) when $\Psi(\cdot)$ is *not* a function of x.[2] That is to say, making the bonus depend on x tends to decrease consumption of x. Unfortunately, BKWW's experimental design was insufficient to test this, as it lacked a group subject to the bonus plan with the probability of winning being independent of consumption.

Of principal concern here is the effect of the bonus payment on the level of electricity consumption. In this regard, the Slutsky equations reveal that the income effect provides the key to the influence of the bonus plan. Specifically, the income effect may be expressed as a linear combination of the two possible lottery payments (recall that γ is the payment received when one loses the lottery):

$$\frac{\partial x}{\partial M} = \frac{\partial x}{\partial \gamma} + \frac{\partial x}{\partial \beta}. \quad (4)$$

In this light one might expect the sign of $\partial x/\partial\beta$ to be ambiguous. This is unfortunately correct. Even when we assume that electricity is a normal good, it is only possible to show that $\partial x/\partial\gamma > 0$. The basic result we have on the sign of $\partial x/\partial\beta$ is that

$$\frac{\partial x}{\partial \beta} \gtrless 0 \text{ as } \frac{\partial}{\partial x} U_2^m(1 - \Psi(x)) \gtrless 0.$$ [3]

This admits a peculiar interpretation to the bonus effect: the bonus will increase consumption of electricity if the probability weighted marginal utility of good 2 (with the bonus) increases as x increases. This is an empirical question since there are several combinations of utility and prior distribution functions where this is or is not true. In fact, as an empirical matter, it might be reasonable to hypothesize that $\partial x/\partial\beta$ changes signs over some range of β, much like the income effect on many food items. If these signs change from negative to positive then there will be an "optimal" bonus plan to encourage energy conservation.

To measure the empirical significance of the bonus payment, the total effect of the BKWW experiment may be decomposed as follows:

$$dx = \left.\frac{\partial x}{\partial p_1}\right|_{dM = x\,dp_1} dp_1 + \frac{\partial x}{\partial \beta} d\beta, \quad (5)$$

[2] This result is derived in the appendix.

[3] This result is derived in the appendix.

where the first term represents the compensated price effect and the second term represents the bonus effect. For the price elasticities computed by BKWW to be correct, $\partial x/\partial\beta$ must necessarily be zero. This is a hypothesis that we can easily test. To do so, we will include both the price rebate and the bonus payment in the estimation of BKWW's model of electricity consumption. These results are presented in the next section.

II. Empirical Results

The model used by BKWW is a two component variance-components model with dummy variables for mean, treatment, and interaction effects. Also, dummy variables are used to control for the effect of the house being empty during the baseline period (when pre-experimental consumption levels are established), during the experimental period, and to control for the effect of each experimental week. The dependent variable is the percentage change in KWHs of electricity use relative to the average consumption during the baseline period. We re-estimated this model using the Wallace-Hussain (1969) estimator of the variances.[4] We were not able to replicate their results exactly; in particular the interaction effects between experimental weeks and the house empty variables were not significant. Further, our estimates of the treatment effects were similar in sign, but not of the same magnitude as those reported by BKWW.[5] These results are presented in the second column of table 1. The first column presents the ordinary least squares (OLS) estimates for comparison. As a check on model specification, we computed the Lagrange Multiplier statistic suggested by Breusch and Pagan (1980). This is a direct test of whether the variance-components model would be preferred to a simple OLS model. The test overwhelmingly rejected the OLS specification in favor of the variance-components model ($\chi^2_{(1)} = 110.9$). In fact, all of our specifications using OLS were rejected in favor of the variance-components model. We then removed the dummy variables used for measuring treatment effects and included the actual price rebate and the potential bonus payment in the model. The actual price rebate was used because each household could calculate this variable from the weekly consumption information provided during the experiment, while the actual bonus payment could not be calculated from this information. These variables al-

[4] BKWW use an alternative approach known as Henderson's Method III (1953) to estimate their model. These different estimation methods tend to give quite similar results, so our estimates should be comparable (Maddala and Mount, 1973).

[5] This is probably due to our inability to locate two households used in the original BKWW study. We only used 105 households for our empirical analyses, whereas BKWW used 107 households.

lowed us to distinguish between the bonus and price effects and to simultaneously separate the treatment groups into those receiving monetary compensation and those not receiving monetary compensation. This separation seems reasonable since we are only concerned with the monetary effects of the experimental design, and thus all non-monetary treatment conditions form the relevant control group.

As mentioned above, only two groups were eligible for the price rebates and bonus payments. The first group, called the High Price Rebate group, was offered a price rebate upon a *percentage* reduction in the weekly KWHs consumed relative to the baseline period. This implied that each household received a different price rebate if their baseline consumption levels differed. We computed these price changes for each household in the High Price Rebate group and found that they ranged from 2.92¢/KWH to 43.95¢/KWH. With the cost of electricity being 2.6¢/KWH during the experiment, the maximum rebate implied a price change of over 1600%. In the second rebate group, called the Low Price Rebate group, every household was paid a uniform rebate of 1.3¢/KWH for reducing electricity consumption relative to the baseline period. The bonus payments were fixed at $10 and $2 for the High and Low Rebate groups, respectively, and were not paid until the end of the initial experimental period.

The results using price rebate and bonus payment variables are presented in the last two columns of table 1. Column three includes all groups in the estimation procedure and column four includes only the rebate groups and the so-called Information group. The Information group was given government pamphlets on energy conservation as a treatment effect. This group is perhaps the most appropriate control group since energy conservation information is often disseminated by the various media organizations, and thus the rebate groups would also receive some information treatment. The most notable feature in these results is that the bonus payment effects are consistently negative and significant in both sets of results, while the price rebate estimates have the right sign but are not significant. This insignificance is unusual and requires further examination. First, it should be noted that the experiment was only short run in nature and thus households would not be making new appliance purchases in response to these relative price changes. As BKWW note, the major response would come through changing utilization rates and our estimates suggest that households are altering these in response to the probabilistic bonus incentive and not to the more certain price rebate incentive.[6]

TABLE 1.—OLS AND VARIANCE - COMPONENTS REGRESSION RESULTS

Variables	(1)	(2)	(3)	(4)
Constant	−18.33	−17.17	−15.83	−20.54
	(−12.22)	(−5.02)	(−2.15)	(−0.94)
House Empty Baseline	1.84	1.80	1.97	2.29
	(1.70)	(0.54)	(0.39)	(0.12)
Week #1	10.33	10.44	10.45	10.88
	(8.48)	(12.64)	(12.90)	(10.10)
Week #2	−15.14	−15.07	−15.07	−14.30
	(−12.45)	(−18.26)	(−18.70)	(−13.10)
Week #3	8.52	8.43	8.42	7.77
	(7.01)	(10.22)	(10.50)	(7.20)
House Empty A	15.61	14.21	14.11	20.48
	(11.13)	(12.52)	(13.61)	(10.89)
House Empty B	3.05	1.57	1.49	9.01
	(1.58)	(1.01)	(0.99)	(4.03)
Treatment #1	−3.45	−3.35	—	—
	(−2.24)	(−0.91)		
Treatment #2	−3.56	−3.39	—	—
	(−2.45)	(−0.98)		
Treatment #3	1.49	1.41	—	—
	(1.12)	(0.64)		
Treatment #4	5.39	5.39	—	—
	(3.68)	(1.38)		
Price Rebate	—	—	−0.046	−0.043
			(−0.55)	(−0.26)
Bonus Payment	—	—	−0.48	−0.59
			(−2.15)	(−1.77)
N	420	420	420	224
R^2	.47	—	—	—

Notes: The figures in parentheses are *t*-ratios. The variables are defined as follows: House Empty Baseline (δ_j) measures the effect of the house being empty 0 days during baseline (δ_1), the house being empty 1 or 2 days (δ_2) is excluded by the restriction $\Sigma \delta_j = 0$; Week #1 (η_1), Week #2 (η_2), and Week #3 (η_3) are measuring the effect of different experimental weeks, the fourth week (η_4) is excluded by the restriction $\Sigma \eta_j = 0$; House Empty A (γ_1) and House Empty B (γ_2) measure the effect of the house being empty 0 days and 1 or 2 days during the experimental period, the effect of the house being empty 3 days (γ_3) is excluded by the restriction $\Sigma \gamma_j = 0$; Treatment #1 (β_1) and Treatment #4 (β_4) measure the effect of different treatment conditions, where Treatment #1 and Treatment #2 refer to the High and Low Rebate groups, respectively, the fifth treatment group is excluded by the restriction $\Sigma \beta_i = 0$.

However, this is not necessarily a robust conclusion. These households are assumed to be monitoring their own electricity consumption, but because they are not paid the bonus or the price rebate until the end of the experiment period, the *actual* price rebate may not be the appropriate variable for measuring price effects. In this circumstance, the *potential* price rebate may be a

[6] Indirect evidence that probabilistic incentives are effective is offered by Selby and Beranek (1981) in their analysis of sweepstakes contests. They find that in over two-thirds of the contests analyzed a risk-neutral or risk-averse individual would not be expected to enter. And yet, sponsors would not continue to offer these events if response rates were low. Thus, perhaps, as Selby and Beranek state (p. 195): "these people may be dominated by nonpecuniary motives: pleasures of gambling or use of leisure time."

more appropriate variable. Unfortunately, for the High Rebate group this is not defined until the end of the experimental period because it is based on a percentage of actual consumption and for the Low Rebate group it is not distinguishable from the potential bonus payment variable. Hence, we did not attempt to estimate this model, although one implication of this observation is that the bonus variable may be capturing some of the price rebate effect, thus biasing our estimate of the bonus effect upwards.

Further evidence on this question is available from the BKWW results. After the initial experimental period the treatment conditions for the Information group were changed to put these households on a high price rebate plan similar, but not identical, to the plan used with the initial group. This new treatment did not include a bonus payment for energy conservation, and so the consumption response was due only to the price rebate. Without adjusting for the price rebate difference, BKWW (p. 186) find that the original High Rebate group reduced electricity consumption by 8.29% and that the new group reduced consumption by 7.56%. The difference here of 0.73% is the bonus effect.[7] This is smaller than our previous estimate, which implied an average reduction during the initial experimental period of 2.84%. Thus, there is some evidence that our bonus variable might be capturing part of the price rebate effect during the initial experimental period. However, regardless of this possibility, these results seem to indicate that the bonus effect acted to reduce electricity consumption, although its relative importance cannot be determined exactly.

The compensated price elasticity and bonus elasticity estimates derived from the figures in table 1 are both very small (less than 0.18 in absolute value). This is similar in magnitude to what BKWW reported when the bonus and price effects were combined into one elasticity measure.

III. Conclusions

In our analysis we have shown that the use of bonus payments in an experimental study of electricity demand is directly related to the income effects in the Slutsky equation. As with the income effect it is not possible to predetermine the sign of the bonus effect; a result that holds even if we are considering normal goods. The reason for this is tied to the fact that the probability of receiving the bonus payment is related to a given household's level of consumption. This situation occurs because of the special nature of the BKWW experiment. Further, our theoretical results predict that if the relationship between the bonus payment and consumption of electricity is severed, then households would unambiguously increase consumption.

The experiment conducted by BKWW provided data on households' consumption responses to different bonus payment and price rebate plans. The original results reported by BKWW did not separate the bonus effect from the price rebate effect. In re-estimating their model to isolate these effects, we found that both the bonus payments and price rebates tended to have a negative effect on consumption. Thus, we conclude that bonus plans like BKWW's will reduce electricity consumption and could be an alternative approach to promoting conservation.

[7] We were not able to determine if this difference was significant due to our inability to replicate exactly the BKWW results. However, in our regressions, the difference was not significant.

APPENDIX

PROPOSITION 1: *$x^{**} < x^*$, where x^{**} solves* (3) *and x^* is the solution to*

$$G'(x) = (\Psi)\partial U^n/\partial x + (1-\Psi)\partial U^m/\partial x = 0$$

for Ψ an appropriate constant, if $\beta > \gamma$ and $U(\cdot)$ is concave and increasing in x.

Proof: $0 = G'(x^{**}) + (U^n - U^m)\Psi'(x^{**})$. With $\beta > \gamma$ and U increasing we have

$$(U^n - U^m)\Psi'(x^{**}) < 0$$

and thus $G'(x^{**}) > 0$. With U concave, $G''(x) < 0$. Hence, because $G'(x^{**}) > G'(x^*)$ and $G'(\cdot)$ is decreasing in x, we have $x^{**} < x^*$.

PROPOSITION 2: $\dfrac{\partial x^{**}}{\partial \beta} \gtreqless 0$ *as* $\dfrac{\partial U_2^m(1-\Psi)}{\partial x^{**}} \gtreqless 0.$

Proof: Differentiate (3) with respect to β, to obtain

$$0 = \left(\frac{\partial^2 H}{(\partial x)^2}\right)\frac{\partial x^{**}}{\partial \beta} + \frac{1}{p_2}\left[\left(U_{12}^m - \frac{p_1}{p_2}U_{22}^m\right)(1-\Psi) - U_2^m\Psi'\right].$$

Thus, since x^{**} maximizes H, $\partial x^{**}/\partial\beta$ has the same sign as

$$\left(U_{12}^m - \frac{p_1}{p_2}U_{22}^m\right)(1-\Psi) - U_2^m\Psi' = \frac{\partial U_2^m(1-\Psi)}{\partial x^{**}}$$

as desired.

To show that the ambiguity in signs still holds when we assume that electricity is a normal good it is sufficient to show that $(U_{12}^m - (p_1/p_2)U_{22}^m)$ is positive by the normality assumption. This is trivially the case.

REFERENCES

Battalio, Raymond C., John H. Kagel, Robin C. Winkler, and Richard A. Winett, "Residential Electricity Demand: An Experimental Study," this REVIEW 61 (May 1979), 180–189.

Breusch, T. S., and A. R. Pagan, "The Lagrange Multiplier Test and Its Applications to Model Specification in Econometrics," *The Review of Economic Studies* 47 (Jan. 1980), 239–254.
Eden, Benjamin, "The Insurance-Buying Gambler," *Economic Inquiry* 18 (July 1980), 504–508.
Henderson, Charles F., "Estimation of Variance and Covariance Components," *Biometrics* 9 (June 1953), 226–252.
Hill, Daniel H., Deborah A. Ott, Lester D. Taylor, and James M. Walker, "Incentive Payments in Time-of-Day Electricity Pricing Experiments: The Arizona Experiment," this REVIEW 65 (Feb. 1983), 59–65.
Maddala, G. S., and T. D. Mount, "A Comparative Study of Alternative Estimators for Variance Components Models Used in Econometric Applications," *Journal of the American Statistical Association* 68 (June 1973), 324–328.
Selby, E. B., and W. Beranek, "Sweepstakes Contests: Analysis, Strategies, and Survey," *American Economic Review* 71 (Mar. 1981), 189–195.
Spence, Michael, and Richard Zeckhauser, "The Effect of the Timing of Consumption Decisions and the Resolution of Lotteries on the Choice of Lotteries," *Econometrica* 40 (Mar. 1972), 401–403.
Wallace, Thomas D., and Ashiq Hussain, "The Use of Error Components Models in Combining Cross Section with Time Series Data," *Econometrica* 37 (Jan. 1969), 55–72.
Winett, Richard A., and Michael T. Nietzel, "Behavioral Ecology: Contingency Management of Consumer Energy Use," *American Journal of Community Psychology* 3 (June 1975), 123–133.

AN ALMOST IDEAL DEMAND SYSTEM INCORPORATING HABITS: AN ANALYSIS OF EXPENDITURES ON FOOD AND AGGREGATE COMMODITY GROUPS

Laura Blanciforti and Richard Green*

I. Introduction

Recently Deaton and Muellbauer (1980a) have developed and estimated a demand system which they refer to as almost ideal (AIDS).[1] When their demand system was applied to annual British data from 1954 to 1974, Deaton and Muellbauer (1980a) found plausible structural parameter estimates and reasonable price and income elasticity estimates; however, homogeneity and symmetry restrictions were rejected. Based on these and other results they concluded that influences other than current prices and current total expenditure must be explicitly incorporated into the model to explain consumer behavior in a theoretically coherent and empirically robust way. They suggest generalizing their static model by adding dynamic elements and including other factors to improve their original framework. Ray (1980), in this *Review*, extended the AIDS by including family size and applying it to Indian budget data.

The purpose of this paper is to make the AIDS dynamic by incorporating habit effects after the manner of Pollak and Wales (1969). By explicitly including this dynamic structure into the AIDS, the temporal relationships between price and income elasticity estimates can be examined. The homogeneity and symmetry restrictions which were rejected by Deaton and Muellbauer (1980a) are tested with the more dynamic generalized AIDS to determine if the exclusion of dynamic elements may have accounted for their result. The results indicate that habit formation is the reason for the autocorrelation found in the residuals of the demand equations.

The outline of the paper is as follows. In section II, the almost ideal demand system is extended by explicitly including habit effects. The stochastic specifications together with the estimation procedures are then discussed. In section III, the static and dynamic models are estimated for 11 aggregate commodity and 4 food commodity classifications using annual United States data for years 1948 to 1978. The structural parameter estimates, price and income elasticity estimates, habit effects and the results from testing various restrictions by the likelihood ratio method are reported in this section. The results are compared with those obtained by others for similar commodity classifications. Conclusions following from the results of the application are given in the final section.

Received for publication November 9, 1981. Revision accepted for publication November 12, 1982.

* United States Department of Agriculture, ERS; and University of California-Davis, respectively.

This research was carried out under a cooperative agreement (#58-3J23-0-0286X) with the United States Department of Agriculture and the Department of Agricultural Economics, University of California-Davis. A tremendous debt of gratitude is owed to Gordon King, Stanley Johnson and Sylvia Lane for useful comments and suggestions. Giannini Foundation Paper No. 671.

[1] The immodest title stems from the properties associated with their system. Deaton and Muellbauer (1980a, p. 312) list the following advantages of their system: (1) it gives an arbitrary first-order approximation to any demand system; (2) it satisfies the axioms of choice exactly; (3) it aggregates perfectly over consumers; (4) it has a functional form which is consistent with previous household-budget data; (5) it is simple to estimate (in the linear approximate form); and (6) it can be used to test for homogeneity and symmetry.