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Memorandum

To: Dave Nichols, ComEd

From: Navigant Consulting, Inc.

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Re: Revenue neutral model of free ridership

This memo concerns a model of revenue neutral behavior by retailers for estimating free ridership for upstream lighting programs, as detailed in ODC's slide deck, "Revenue Neutral Model: A New Approach to Estimating Free Ridership for Upstream Lighting Programs", October 2012. The slide deck is attached.

The memo is organized as follows. First, we outline two major concerns about the approach. We then make several recommendations for additional research, and conclude with a recommendation for use of the method by ComEd in the PY5 program year.

Issue #1: The Underlying Model of Retailer Behavior

The approach relies on the premise that retailers will participate in a program if it is revenue neutral—that is, if it generates revenue that is no lower than the revenue the firm receives without the program. There are two conceptual concerns with this premise. The most obvious is that standard economic theory conceives of firms as profit maximizers, in which case a firm might well choose to participate in a program that lowers revenues if it increases profits (earnings). Casting revenue neutrality as a necessary condition for program participation is a rejection of this standard model of behavior. The presentation provides no theoretical or empirical support for the assertion.

The second concern is that the presentation does not provide a general model of firm (or management) behavior in support of revenue neutrality. In other words, if retailers are not profit maximizers, what do they maximize (or minimize)? What is the retailer's objective function that is consistent with revenue-neutral behavior, and does it provide a set of testable implications that can be examined empirically? From Navigant's perspective, revenue-neutrality is not a model of firm behavior per se, but rather a derived condition that must arise from a more general model of firm behavior consistent with the firm's pre-program behavior. It is difficult to justify, for instance, the claim that the initial position of the retailer is derived from profit maximization, but that the retailer is not a profit maximize when it comes to the decision about whether to participate in a lighting

program. Ideally, compelling theoretical and empirical support of the alternative model would be gathered to reject the standard model of firm behavior (i.e. profit maximization).

Importantly, the presumption of revenue neutrality with respect to program participation is *not* consistent with revenue maximization as a model of firm/management behavior. If a firm is a revenue maximizer, then participation in a new lighting program is necessarily rejected by the firm, because the firm is, by assumption, already maximizing revenue. This conclusion contrasts with a model of profit maximization, which is *not* structurally inconsistent with a firm's decision to participate in a lighting program.

There may be models of firm or management behavior that at least partially support revenue neutrality as a condition for program participation. Suppose, for instance, that firms are profit maximizers, and profits are known to be highly correlated with the top-line calculation of revenue, in which case revenue neutrality is a good proxy for profit neutrality. In other words, firms participate in the program only if their profits do not fall, and, due to high correlation between revenues and profits, this implies participation only if revenues do not fall. Unfortunately, the correlation between profits and top-line revenue as defined in the ODC slide deck is likely to be low because the top-line revenue calculation nets out the value of the rebate. Nonetheless, the basic question –is there a model of firm behavior consistent with the revenue-neutrality assumption –is worth additional investigation.

It would be no surprise if the decision to participate in a lighting program depended on a weighting of *both* profits and revenue –i.e, a weighting of the top line and bottom line of a firm's balance sheet. But the proposed model is inconsistent with this notion of joint objectives, because the condition of revenue neutrality allows no trade-off between gains in profits and loss of revenue.

Issue #2: The Free Ridership Estimate under the Revenue Neutrality Condition is an Upper Bound

Revenue neutrality implies that a firm participates in a lighting program if revenue under the program is *no less* than revenue without the program. The implication of this is that the estimate of free ridership is an upper bound; the actual free ridership under the program is no higher than the estimate, and could be lower.

To illustrate, we use the example provided on slide 18 of the presentation. Initially the price is $1 per unit and the firm sells 100 units to generate $100 in revenue. Under the assumption of revenue neutrality, the firm will participate only if revenue is at least $100. At $0.50 per unit, this requires selling *at least* 200 units. As shown in slide 18, the free ridership ratio in this case is 100/200=.5. That is, half of the sales would have occurred without the program.

But free ridership in the example could be lower –perhaps much lower. Suppose, for instance, that in the absence of the program the firm sells 50 units (this is the piece of data in the calculation not known by the analyst), generating $50 in revenue. In this case the program satisfies revenue neutrality ($100 > $50) and yields an estimate of free ridership of 50/200=.25. In other words, the firm participates in the program if counterfactual sales are *anything less* than 100 units.

The upper bound on free ridership is the ratio of the prices before and after the rebate. To see this formally, we define revenue by R, the price of a unit by P, and the quantity of a unit by Q. Subscripts are used to define values with (1) and without (0) the program; for instance, R_1 and R_0 indicate revenue with and without the program, respectively. The revenue neutrality condition requires,

(1) $R_1 \geq R_0 \rightarrow P_1 \cdot Q_1 \geq P_0 \cdot Q_0$.

This generates an inequality condition for the unobserved variable Q_0:

(2) $Q_0 \leq (P_1 \cdot Q_1)/P_0$.

Defining the free ridership quotient by $FR = Q_0/Q_1$, we obtain the upper bound on free ridership by dividing (2) by Q_1:

(3) $FR \leq (P_1 \cdot Q_1)/(P_0 \cdot Q_1) \rightarrow FR \leq P_1/P_0$

In other words, the ratio of the prices provides an upper bound on free ridership.

The slide presentation continues to consider the case where final program sales are different than sales goals. Denoting sales goals by $E\{Q_1\}$ –that is, "expected program sales" –and actual program sales by Q_1, algebra similar to the above generates the following modified inequality constraint for the free ridership quotient:

(1) $FR \leq (P_1 \cdot E\{Q_1\})/(P_0 \cdot Q_1) \rightarrow FR \leq (P_1/P_0) \cdot (E\{Q_1\}/Q_1)$.

In words, the upper bound on free ridership is now defined by the product of the ratio of prices and the ratio of expected/actual sales. When sales goals are met exactly, $E\{Q_1\}=Q_1$, this simplifies to (3). The important point is that it is still the case that the calculation of free ridership is an upper bound, after correcting for differences between sales goals and actual sales.

The discussion above has two clear implications. First, the lower the rebate, the higher the upper bound on free ridership and thus the less useful the method becomes. A rebate of 10%, for instance, generates a free ridership upper bound of 90% in the case where $E\{Q_1\}=Q_1$ —not a very useful piece of information.

Second, over the range of prices for which price elasticity of demand is greater than 1 (elastic demand), *any* rebate program will be accepted under the assumption of revenue neutrality because in this case revenue always increases with a reduction in price. The inverse must also be true: over the range of prices for which price elasticity of demand is less than one (inelastic demand), *no* rebate will be accepted, because in this case no decrease in price results in revenue neutrality. In a competitive market, the price elasticity of demand associated with a rebate depends on the extent of the program; the lower the market share of participating retailers, the greater the elasticity of demand. This line of reasoning may be worth pursuing, as it might be a source of good testable hypotheses about the model.

Recommendations

The method presumes that revenue neutrality is a necessary condition for participation in a lighting program. This presumption is at odds with standard economic theory and therefore requires supporting material that could arise in several forms:

1. Development of a model of firm/management behavior that is consistent with revenue neutrality as a necessary condition for entry in a lighting program. As noted above, neither profit maximization nor revenue maximization is consistent with revenue neutrality as a condition for program participation.

2. Identification and testing the implications of the behavioral model developed in recommendation #1. Does the model produce implications that can be tested using available data, perhaps including survey data? Successfully testing the model provides support for revenue neutrality.

3. Evidence from published statistical studies indicating that under certain conditions firm/management behavior can be consistent with revenue neutrality.

4. Other evidence, such as self-reports by firm decision-makers, that revenue neutrality is a necessary condition for participation in a program like a lighting program.

Summary

As emphasized in the ODC slide presentation about the model, substantial issues afflict current standard methods for estimating free ridership, and attempts to identify cheaper, more accurate approaches should be encouraged. Nonetheless, a new approach bears a burden of proof. Navigant believes this burden has not yet been met by the approach outlined in the slide presentation, and believes additional research, as detailed above, should be conducted in support of the method before it is adopted by ComEd.