

# ESTIMATING THE INFLUENCE OF PUBLIC POLICY ON ROAD TRAFFIC LEVELS IN GREATER LONDON

## A Comment

By Leonard R. Roueche\*

In a recent article [1] in this Journal, Lewis attempts to forecast changes in the level of road traffic due to changes in public transport fare and service levels, petrol prices and demographic and macro-economic activity. This is a commendable first step in estimating such a forecasting model, but the author completely ignores the influence of road congestion on the level of traffic. The result of this omission is likely to be an overestimate of the impact of public policy on road traffic levels.

The single equation model assumes that the volume of road traffic is a function of petrol prices, public transport fare and service levels, disposable income and population. The influence of road congestion on traffic levels is totally ignored. There are several ways in which congestion could influence road traffic volume. Increased petrol prices, reduced public transport fare levels, and increased public transport service levels could each act to reduce road traffic levels by encouraging substitution from private cars to public transport. Lewis's model ends here, but in fact the adjustment process would continue further before final equilibrium was achieved. The reduced road traffic levels would improve the service characteristics of private auto travel, and thus some people would return to private autos. So Lewis's model would forecast a greater reduction of road traffic levels from public policy changes than would actually be realised.

In addition, he has ignored the interrelation between road traffic and bus service levels. Public policy to encourage substitution of public transport could have a differential effect on bus and underground riderships. Suppose petrol taxes were increased, thus increasing public transit ridership and reducing road traffic. We suggested above that this shift would be followed by a countershift back to private autos in response to improved private car service levels. Simultaneously, however, bus service would also improve, causing some travellers to shift from underground transport to bus transport. The end result would be higher road traffic levels and a greater proportion of public transport travellers using buses (as opposed to the underground) than would be predicted from Lewis's model.

Lewis's model is a first step in developing a forecasting model. The next step is to formulate a more sophisticated simultaneous system, which specifies: (1) some measure of road traffic congestion as an explanatory factor of road traffic levels; (2)

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that road traffic congestion is a function of road traffic levels; and (3) that bus service levels are a function of road traffic levels and congestion. If data is available on average road speeds, an attempt could be made to estimate this simultaneous system. If not, it might be worth while to devise a system for collecting that information in conjunction with hourly vehicle flows.

## A Rejoinder

### By David Lewis

I agree with L. R. Roueche that it is appropriate to write down a simultaneous equation process to represent the interaction of traffic volume and traffic speed (or an alternative measure of road congestion); for example, the following two-equation system (where the  $\gamma_i$  are coefficients of endogenous variables, the  $\beta_i$  coefficients of exogenous variables, and use is made of the general specification in the original article [3]);

*Structural form*<sup>1</sup>

$$LN V_t = \delta_0 + \gamma_1 LN C_t + \beta_1 LN G_t + \beta_2 LN F_{t-1} + \beta_3 \frac{I}{S_{t-1}} + \beta_4 LN Y_t + \beta_5 LN P_t + \epsilon_t \quad (1)$$

$$LN C_t = \delta_1 + \gamma_2 LN V_t + \mu_t \quad (2)$$

*Reduced form*

$$LN V_t = \frac{\delta_0 + \gamma_1 \delta_1}{1 - \gamma_1 \gamma_2} + \frac{\beta_1}{1 - \gamma_1 \gamma_2} LN G_t + \frac{\beta_2}{1 - \gamma_1 \gamma_2} LN F_{t-1} + \frac{\beta_3}{1 - \gamma_1 \gamma_2} \frac{I}{S_{t-1}} + \frac{\beta_4}{1 - \gamma_1 \gamma_2} LN Y_t + \frac{\beta_5}{1 - \gamma_1 \gamma_2} LN P_t \quad (3)$$

$$LN C_t = \frac{\delta_1 + \gamma_2 \delta_0}{1 - \gamma_1 \gamma_2} + \frac{\gamma_2 \beta_1}{1 - \gamma_1 \gamma_2} LN G_t + \frac{\gamma_2 \beta_2}{1 - \gamma_1 \gamma_2} LN F_{t-1} + \frac{\gamma_2 \beta_3}{1 - \gamma_1 \gamma_2} \frac{I}{S_{t-1}} + \frac{\gamma_2 \beta_4}{1 - \gamma_1 \gamma_2} LN Y_t + \frac{\gamma_2 \beta_5}{1 - \gamma_1 \gamma_2} LN P_t \quad (4)$$

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<sup>1</sup>The double-log linear form of the speed/flow curve follows Walters [4]. A more realistic formulation would complicate the formal analysis but would not alter the fundamental conclusion to follow.

where

V (endogenous)	denotes	traffic volume
C (endogenous)	denotes	traffic congestion (say speed)
G (exogenous)	denotes	petrol price
F	,,	public transport fare level
S	,,	public transport service level
Y	,,	disposable income
P	,,	population

The reduced form equation (3) is, however, a re-statement of the equation estimated in the original article (where  $\eta_{v,x}$  = the elasticity or cross-elasticity of V with respect to variable X);

$$\begin{aligned} \text{LN } V_t = & \alpha_0 + \eta_{(v,g)} \text{LN } G_t + \eta_{(v,f)} \text{LN } F_{t-1} \\ & + \alpha_1 \frac{1}{S_{t-1}} + \eta_{(v,y)} \text{LN } Y_t + \eta_{(v,p)} \text{LN } P_t \end{aligned} \quad (5)$$

where:

$$\alpha_0 = \frac{\delta_0 + \gamma_1 \delta_1}{1 - \gamma_1 \gamma_2}, \eta_{(v,g)} = \frac{\beta_1}{1 - \gamma_1 \gamma_2}, \eta_{(v,f)} = \frac{\beta_2}{1 - \gamma_1 \gamma_2},$$

$$\eta_{(v,s)} = -\frac{\beta_3}{1 - \gamma_1 \gamma_2} \frac{1}{S}, \eta_{(v,y)} = \frac{\beta_4}{1 - \gamma_1 \gamma_2}, \eta_{(v,p)} = \frac{\beta_5}{1 - \gamma_1 \gamma_2}$$

Thus, rather than ignoring the influence of road congestion, the estimated parameters measure the *total impact* on traffic volume of a change in the exogenous variables. The total impact can be seen to consist of two parts: the *direct* effect on traffic volume measured by the  $\beta_i$  and the *indirect* effects via the interaction of speed and flow measured by  $(1 - \gamma_1 \gamma_2)$ . Note that  $\gamma_2 \leq 0$  and  $\gamma_1 \geq 0$ , so that the total impact will always be equal to or less than the direct effect, as Roueche suggests it should be.<sup>2</sup> The argument can be developed for the effects of bus speed and public transport demand if larger simultaneous systems are considered.

#### IDENTIFICATION AND POLICY ANALYSIS

In practice we could not identify the structural parameters in equations (1) and (2) with Indirect Least Squares, as the system is over-identified. Rather, some means other than ILS would have to be used, probably Two Stage Least Squares or Maximum Likelihood. For policy analysis, however, one might question the benefits of trying to do this, in view of the considerable cost and difficulty of devising a system for recording adequate hourly data on area congestion. OLS applied to the reduced form equation (3) yields unbiased and consistent estimators of the full effect of interest to the decision maker who is trying to influence congestion (as well as air quality and fuel consumption).

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<sup>2</sup>If time is used as the measure of congestion, then  $\gamma_2 \geq 0$  and  $\gamma_1 \leq 0$ .

## CONCLUSION

This is not to say that the demand parameters in a model like equation (3) are not in reality jointly determined with the *demand* parameters for competing travel modes, and in this aspect of simultaneity I share Roueche's concern. For example, it is impossible, using the single equation model, to check Slutsky's conditions for consistent consumer behaviour, in particular the symmetry of the compensated substitution matrix [1]. If the consumer is to behave consistently, choice theory predicts that the substitution effect on the quantity of mode *i* consumed in response to a change in the price of mode *j* must be the same as the substitution effect on mode *j* of the same change in the price of mode *i*. Thus the estimation of a complete travel demand system subject to the normal Slutsky constraints would, in my opinion, represent a more promising line of further research.

## A CORRECTION

Further work undertaken since publication of my original article [3] has revealed a fault in the Greater London Council computer package which was used in estimating equation (5) above. The fault occurred with the inclusion of the population variable in the regression equations. The program was unable to cope accurately with the very small variation in population over the estimation period, and this caused errors due to rounding. The model has now been re-estimated with an alternative computer program which indicates that population is not a useful predictor (judged against statistical and theoretical criteria). This has led to revisions in the elasticities reported in Table 6 of [3]: these are shown here in a revised Table 6.

REVISED TABLE 6  
Summary of Results—Estimated elasticities and 95% confidence limits

<i>Model estimate of</i>	<i>Period Peak</i> (0700–1000)	<i>Monday–</i> <i>Friday</i> (24 hr.)	<i>Saturday</i> (24 hr.)	<i>Sunday</i> (24 hr.)	<i>Monday–</i> <i>Sunday</i> (24 hr.)
Petrol price elasticity	–0.024 (±0.084)	–0.076 (±0.046)	–0.360 (±0.194)	–0.369 (±0.192)	–0.067 (±0.047)
Cross-elasticity with respect to fares	0.084 (±0.084)	0.051 (±0.076)	–0.044 (±0.348)	0.079 (±0.345)	0.080 (±0.081)
Cross-elasticity with respect to service level*	–0.108 (±0.107)	–0.062 (±0.098)	–0.062 (±0.376)	–0.302 (±0.388)	–0.060 (±0.118)
Income elasticity	0.134 (±0.155)	0.097 (±0.140)	0.023 (±0.495)	0.045 (±0.491)	0.168 (±0.141)

\*Evaluated at mean service level, 1972–75

The main conclusions remain unaffected for all variables other than population, which is no longer included in the final model. Thanks are due to N. Wright for help in determining the fault. Further details can be obtained from the author and N. Wright, ref DG/PSIB/M, Greater London Council, London SE1. Thanks are also due to London Transport for the research which indicated the possibility of a fault.

#### REFERENCES

- [1] Brown, A., and A. Deaton: "Surveys in Applied Economics: Models of Consumer Behaviour." *The Economic Journal*, December 1972.
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