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Man-Feng Chang, Leonard Evans, Robert Herman, Paul Wasielewski,

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Letter to the Editor

Fuel Consumption and Right Turn on Red: Comparison between Simple Model Results and Computer Simulation

MAN-FENG CHANG, LEONARD EVANS, ROBERT HERMAN, and PAUL WASIELEWSKI

Research Laboratories, General Motors Corporation, Warren, Michigan

In a recent presentation, LIEBERMAN AND COHEN[1] calculated the effect on fuel economy and emissions of permitting a right turn on red at signalized intersections. They applied a detailed computer simulation to a network of streets in Washington, D.C. Fuel consumption was obtained by adding up the fuel used to execute each individual maneuver.

It is the purpose of this note to point out that, once the change in the average speed in a traffic system has been determined, the change in fuel consumption can be immediately derived using a simple model of the dependence of urban fuel consumption on average traffic speed without the necessity of performing the detailed fuel summation.

The model was derived by analyzing data collected by driving in low speed urban traffic. We found that the fuel consumed per unit distance, ϕ, could be expressed as a linear function of the average trip time per unit distance, $\bar{t}$,[2-4] i.e.,

$$\phi = k_1 + k_2\bar{t}, \qquad (\bar{v} \lesssim 60 \text{ km/h}) \tag{1}$$

where k_1 and k_2 are vehicle dependent parameters[3, 4] and $\bar{v} \equiv 1/\bar{t}$ is the average trip speed.

The fuel economy and speed information given in Table I of Lieberman and Cohen's paper[1] provides an opportunity to illustrate the application of the model, which is essentially summarized by Equation (1). The reciprocals of the "mean speed" and "miles per gallon" values given in that table yield the six $(\bar{t}, \phi)$ pairs which are plotted in Figure 1.

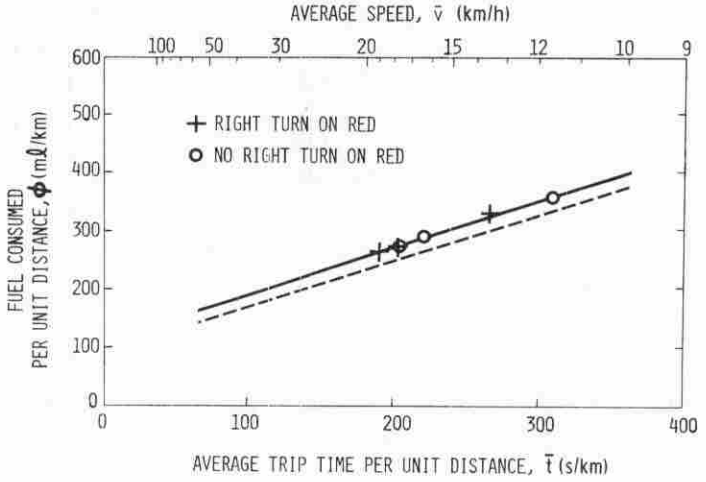

Fig. 1. Fuel consumption per unit distance versus trip time per unit distance derived from simulation results of Lieberman and Cohen.[1] The *solid straight line* is a linear regression to the data plotted. The *dashed line* corresponds to Equation (1) with the intercept k_1 and the slope k_2 determined by averaging the individual values obtained for seven vehicles studied in the field.[4] Both lines are plotted only for the range of $\bar{t}$ where the linear model is applicable.

The model implies that such data, if obtained by driving in urban traffic, would lie on a straight line of the form of Equation (1). The six points in Figure 1 do indeed fit a straight line, indicating agreement in this respect between the simulation results and the model derived from actual driving in urban traffic. Equation (1) is equally successful in accounting for both fuel consumption changes due to changes in traffic volume and those due to the institution of the right-turn-on-red policy.

The parameter values obtained from a regression on these data, $k_1 = 114$ ml/km and $k_2 = 0.80$ ml/s, are consistent with the averages obtained for the seven vehicles we tested [4, 5] namely, $k_1 = 89$ ml/km and $k_2 = 0.79$ ml/s.

Lieberman and Cohen quite correctly point out that fuel consumption at a constant speed does not provide a good estimate of fuel consumption in traffic at the same mean speed. However, as our work[2-5] indicates, and as is further borne out by their simulation results,[1] fuel consumption in urban traffic can be estimated from the observed mean speed provided the appropriate relation between mean speed and fuel consumption in traffic is used.

As a further illustration, the percentage increases in fuel economy ($= 1/\phi$) resulting from the right-turn-on-red policy computed from Lieberman and Cohen's detailed fuel consumption calculation are compared in Table I with the corresponding values computed from Equation (1) using the average values of k_1 and k_2 that we obtained in the field and the mean speeds from the simulation. The two sets of results are in relatively good agreement. This suggests that our approach provides a rather simple alternative to a detailed calculation based on individual vehicle

TABLE I

Percentage Fuel Economy Improvements Resulting from Right-Turn-on-Red Policy from Lieberman and Cohen's Results[1] *and from Our Approach Using Equation (1) with* $k_1 = 89$ *ml/km and* $k_2 = 0.79$ *ml/s*

Volume	Percentage Improvement in Fuel Economy	
	From Lieberman and Cohen[1]	From our Equation (1)
	%	%
Base level	4.8	5.7
20% Increase	8.9	11.2
20% Decrease	4.0	4.5

trajectories for evaluating changes in fuel consumption associated with various operating policies in urban traffic in cases where the effect on mean speed can be estimated by simulation or other means.

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