Abridgment

Estimating the Impacts of Ramp-Control Programs

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ABSTRACT

Time-series designs offer flexible, low-cost tools for evaluating transportation improvements. Some preliminary estimates of ramp-control impacts on an urban freeway are presented.

Traffic engineering studies (1) provide useful tools for evaluating transportation improvements, but because these studies usually require special commitments of resources to gather and process data, they are unsuited for day-to-day monitoring of the transportation system. Recent advances in computer technology have made automatic data collection feasible for freeway surveillance and control (2), transit system monitoring (3), and intersection control (4). With such low-cost data sets, research designs based on time-series analysis (5,6) can be used routinely to evaluate transportation system improvements. A workable methodology for analyzing such data, despite missing values and statistical dependencies, has been described elsewhere (7,8). In this paper some pilot results that describe the effects of on-ramp controls on Seattle's Interstate 5 (I-5) are presented.

STUDY DESIGN

After discussion with employees of the Washington State Traffic Systems Management Center (TSMC), controlled and uncontrolled locations on I-5 were selected. The controlled location was within the section of I-5 subject to ramp controls, whereas the uncontrolled location was about 5 miles south of the controlled location and about 1.5 miles south of the entire ramp-control region. Data from the uncontrolled location were used as a proxy for exogenous effects such as seasonal trend, fuel price changes, and weather. Thus the uncontrolled location provided a covariable in the sense of analysis of covariance. Five-minute volume counts from 6:00 to 10:00 a.m. for July 1, 1981, through December 17, 1981, were provided by the TSMC. The ramp-control program began on September 30, 1981.

Equation 1 gives the linear regression model that was used to estimate the ramp control impacts:

$$DV_t = b_0 + b_1 IN_t + b_2 CO_t + u_t \quad (1)$$

where

DV_t = dependent variable value on day t;
IN_t = 0 on days before 9/30/81, and 1 on days after 9/30/81;
CO_t = covariable value on day t;
u_t = regression residual on day t; and
b_0, b_1, b_2 = regression coefficients to be estimated.

The intervention variable allows the estimation of changes that correspond to the onset of the ramp-control program. For each dependent variable, the regression coefficients were first estimated by using ordinary least-squares and, when necessary, reestimated by using special methods for handling time-series with missing values. Details can be found elsewhere (6-10).

PRELIMINARY RESULTS

A first study investigated the effect of the ramp controls on peak-period traffic volumes. The peak-hour volume and the volume from 6:30 to 8:00 a.m. (the time period during which the ramp controls operated after September 30, 1981) were calculated for each day for both the controlled location and the study location. These results are given in Table 1. Surprisingly, the volumes decreased in response to the ramp controls. This effect could result from the ramp controls acting to keep volumes at somewhat below capacity, thus improving travel times by restricting access to the freeway. A more detailed investigation of this point is in progress.

TABLE 1 Effects of the Ramp-Control Program

Dependent Variable	Control Effect (vehicles)	Control Effect (vehicles/lane/hr)	Significance
Peak-hour volume	-384.3	-96.1	$p < 0.01$
6:30 - 8:00 a.m. volume	-582.4	-97.1	$p < 0.01$
6:00 - 6:30 a.m. volume	96.8	48.4	$p < 0.01$
8:00 - 8:30 a.m. volume	9.3	4.7	$p > 0.05$
6:00 - 10:00 a.m. volume	-276.6	-17.3	$p > 0.05$

It was also of interest to know whether this volume decrease resulted in temporal or spatial demand shifts; that is, are travelers using a different route or the same route at a different time? Traffic volumes from 6:00 to 6:30 a.m., 8:00 to 8:30 a.m., and 6:00 to 10:00 a.m. were calculated, and ramp-control effects were estimated by using Equation 1. These results also appear in Table 1. The 6:00 to 6:30 a.m. period has a definite increase in volume, whereas the other two periods have no change. It appears then that the ramp controls have flattened the morning peak by shifting some trips to off-peak times.

CONCLUSION

Fine-tuning a ramp-control program to keep it current with the evolution of an urban system will usually require more precise information than that available from simple before-and-after studies. In this paper it has been demonstrated how time-series methods can provide some of this information at the required level of precision. These topics are currently being investigated in greater detail.

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REFERENCES

1. P.C. Box and J.C. Oppenlander. Manual of Traffic Engineering Studies, 4th ed. ITE, Arlington, Va., 1976.
2. P.F. Everall. Urban Freeway Surveillance and Control. Office of Research, FHWA, U.S. Department of Transportation, 1973.
3. M.J. Miner, B. Kliem, and P. Segota. Automatic Vehicle Monitoring: The Los Angeles Experimental System. Proc., International Conference of Cybernetics and Society, 1980.
4. P.S. Tarnoff. Concepts and Strategies--Urban Street Systems. Presented at International Symposium on Traffic Control Systems, Berkeley, Calif., 1979.
5. D.T. Campbell. Reforms as Experiments. American Psychologist, Vol. 24, 1969, pp. 409-429.
6. G.E.P. Box and G.C. Tiao. Intervention Analysis with Applications to Environmental and Economic Problems. Journal of the American Statistical Association, Vol. 70, 1975, pp. 70-79.
7. G.A. Davis. Time-Series Designs and Freeway Surveillance. Master's thesis. University of Washington, Seattle, 1984.
8. G.A. Davis and N.L. Nihan. Using Time-Series Design to Estimate Freeway Level of Service, Despite Missing Data. Transportation Research, Part A (in preparation).
9. W. Dunsmuir and P.M. Robinson. Estimation of Time-Series Models in the Presence of Missing Data. Journal of the American Statistical Association, Vol. 76, 1981, pp. 560-568.
10. R.H. Jones. Time-Series Regression with Unequally Spaced Data. Working Paper. Department of Biostatistics, University of Colorado, Boulder, 1983.

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Description of a Combined Approach for Arterial Signal Coordination Considering Bandwidth and Delays

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ABSTRACT

The coordination of traffic lights on arterial streets can be achieved by maximizing the bandwidth or by trying to minimize delays and stops encountered on the artery and on the side streets. Both of these approaches have advantages that are partly retained in a compromise solution, where a green band is selected from among several possible bands so as to cause the least delay to the driver. A first step in this direction is described by giving the outline of a program that analyzes the relation among delays, speeds, offsets, bandwidths, and cycle lengths over a wide range of speeds and cycles. This program can be used by the practitioner to obtain the speed (for a given cycle length) that maximizes the bandwidth, or to determine the cycle (for a given speed) that maximizes bandwidth. It can also be useful to find the offset, speed, or cycle length that causes a reasonable delay to the driver while retaining an acceptable green band. The program that combines bandwidth maximization and delay minimization was applied to five data sets taken from the literature. It was found that the new approach is feasible and could have economic advantages. It was further found that, for low traffic volumes and no platoon dispersion, there is a relation between bandwidth and delays; larger bands generally result in less delay than smaller ones. But as dispersion and traffic volumes increase, this relation no longer holds. It was also strongly confirmed in all cases studied that delays increase with longer cycle lengths for a given value of K = C • V, and it was shown that there is a tendency for increasing delay with increasing cycle length for a given speed on the artery.

Traffic signal coordination on arterial streets that are not part of a network remains an important problem for the traffic engineer. Two approaches to the coordination of traffic lights are available: bandwidth maximization, and the minimization of a disutility function, which is measured in terms of delays, stops, fuel consumption, and air pollution. Both of these ways of solving the problem have advantages, and an approach that combines these two methods would be of interest. This would retain the undoubtedly important advantage of the psychological effect of the green band and, at the same time, would be more efficient in terms of delays and stops and reducing fuel consumption and time lost by the driver.

There are many variables that intervene in the solution of the problem. Delays and stops on a coordinated artery depend on signal settings, offsets and bandwidth, platoon size, dispersion, and platoon speed. Relatively little is known about the relationships between these variables. Certain intuitive notions, such as the idea that the larger