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Abridgment

Modal-Choice Analysis of an Exclusive Bus and Car-Pool Lane

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Since the Delaware Valley Regional Planning Commission (DVRPC) adopted its 1985 regional transportation plan in 1969, changes in attitudes and conditions have impeded the implementation of that plan. Neighborhoods have become resistant to major new highway construction. Citizens and legislative bodies have demanded that environmental impacts of plans and projects be fully assessed. Escalated construction costs have made the building of all of the facilities shown on the 1985 plan impossible. Federal ambient air quality standards have required that automobile emissions be reduced. Energy shortages have necessitated complete reevaluation of transportation policies.

Of significant impact to the Delaware Valley region are recent revised regulations of the U.S. Environmental Protection Agency (EPA) concerning air quality and regulations of the U.S. Department of Transportation concerning transportation planning and programming. In 1975 the New Jersey Department of Transportation requested the DVRPC to provide an analysis of modal choice in the US-30, I-676, and Lindenwold High-Speed Line corridor (Pennsauken Township-Camden City). This analysis was part of an assessment of the impact of implementing an exclusive bus and car-pool lane through that corridor. This request was in accordance with the federally mandated New Jersey Transportation Control Plan (NJTCP) that states that each appropriate governmental entity shall establish bus and car-pool lanes on designated traffic flow corridors. One of these designated corridors is the Admiral Wilson Boulevard, a section of US-30 between the Ben Franklin Bridge Plaza and the Camden Airport Circle.

In addition to the NJTCP, EPA also promulgated the Pennsylvania transportation control plan. A section of this plan requires all governmental and public agencies to take the necessary actions to establish a peak-period exclusive bus lane over the Ben Franklin Bridge (US-30) going into Philadelphia in the morning and returning to New Jersey in the evening.

The combination of the two requirements delineates a facility, approximately 6.5 km (4 miles), that during the peak periods would serve primarily those people who reside in South Jersey and work in the Philadelphia central business district (CBD).

The corridor is currently served by the Port Authority Transit Corporation's (PATCO) Lindenwold High-Speed Line, numerous bus routes operated by Transport of New Jersey (TNJ), and four major arterial highways that converge at the Camden Airport Circle. The TNJ bus routes include local service to the city of Camden, feeder service to the PATCO line stations, and express and local service to the Philadelphia CBD.

DELINEATION OF POTENTIAL BUS AND CAR-POOL MARKET

Because the exclusive bus and car-pool lane was nonexistent at the time of this study, its market area was not defined. If a market is to develop, however, it must draw on the users of existing facilities (in the short range), i.e., the high-speed line, existing bus routes, and the highway network. Therefore, the subarea's total travel demand and the interdependence of that demand and the facilities currently offered must be understood before a potential market area for a bus and car-pool lane can be delineated.

The approach for market-area delineation was to overlay maps of the market areas of the existing prime facilities in the study area to form a composite market area. The market area served by the high-speed line was derived from automobile license plate surveys conducted at the train stations by the University of Pennsylvania. The highway network market area was derived by a select-link analysis of the Ben Franklin Bridge and the Admiral Wilson Boulevard. The commuter bus market area was assumed to be the coverage areas of those routes that traverse the general area and provide service to Philadelphia. The resultant composite market area was then modified to conform to DVRPC data collection district boundaries. The Pennsylvania portion was limited to the districts of the Philadelphia CBD because all buses using the facility would be destined for only that area and because the density of destinations there provides the greatest likelihood for car pooling.

Travel-demand matrices were constructed for the market area for the project year 1976. This task involved refining previously derived modal trip tables to agree with current corridor passenger and vehicle flows, demographic data, and employment data. The trip tables were further refined to reflect peak-period travel demand.

MODAL-CHOICE MODELING

In modeling the effect of implementing an exclusive bus and car-pool lane on modal choice in the study corridor, a binary-choice logit model was used. The general form of the model is

$$P_i = V_i \Big/ \sum_{j=1}^{m} V_j$$

where

V_t = EXP [aAPH + b TIME + c (COST/INC) + d],
Pi = probability of choosing mode i,
APH = number of automobiles per household,
TIME = total travel time by mode i,
COST = total travel cost by mode i,
INC = dummy variable for household income,
i, j = different modes 1, 2, . . ., m, and
a, b, c, d = calibration factors.

A tested and calibrated binary-choice formulation (two modes in competition) of the above model was available for the Shirley Highway busway in the Washington, D.C., area.

Values of the independent variables for each interchange (New Jersey district to Philadelphia CBD) were calculated on the basis of existing travel parameters as follows:

1. Automobiles per household and income—1970 census aggregated to transportation analysis districts (values for 1976 assumed equal);
2. Total travel time by mode—based on probable route selection, average peak-period link speeds, and nonnetwork times; and
3. Total travel cost by mode—based on fares, operating cost per kilometer, applicable tolls, and parking charges.

MODEL REPLICATION (QUASI-CALIBRATION) PROCEDURE

When a generally applicable model is transferred from one region to another, some revision might be necessary: The variable coefficients might vary slightly because of regional peculiarities, the methods of measuring the absolute values of the independent or dependent variables might vary, and the choice context might be more or less complex.

To ascertain how well the transferred model could replicate the existing modal percentages, a preliminary set of input data based on existing conditions was used in the model run. As guidelines, existing modal shares were developed at the corridor level. Adjustments were then made until the model satisfactorily replicated the guidelines at the corridor level. The adjustments were made to the values of non-line-haul variables of each interchange by mode. These adjustments affected the terminal times for access and egress, the parking time for automobile, the weighted frequency of service penalty for bus, the change of mode time for the high-speed line, and the pickup time penalty for car pooling. In effect, the results were modifications to the model coefficients. The modifications may be interpreted as proxies for the variation between regions and the introduction of a more complex choice context. However, no such outright claims are made.

MULTIMODAL SOLUTION OF BINARY-CHOICE MODEL

Because the model is one of binary choice, only partial results are derived if each mode is modeled separately. However, four modes (automobile, car pool, bus, and high-speed line) can be related with three binary pairings and a relationship of the modes to some absolute total demand. A simultaneous solution was derived. The following five mode pairs were analyzed: high-speed line versus automobile, high-speed line versus bus, high-speed line versus car pool, automobile versus bus, and car pool versus automobile. The other two mode pairs acted as checks and provided insight into particular shifts in mode choice.

MODAL-CHOICE MODELING OF EXCLUSIVE LANES

Two alternative configurations of exclusive bus and car-pool lanes were analyzed: (a) an exclusive bus and car-pool lane preempted from the non-peak-flow direction traffic lanes (contraflow) and (b) an exclusive bus and car-pool lane preempted from the peak-flow direction traffic lanes.

The contraflow configuration improves existing conditions by providing higher speeds for buses and qualified car pools (three or more passengers) through use of an additional exclusive lane on the boulevard. The contraflow configuration also marginally increases traffic speed in the four remaining lanes through a reduction in the number of vehicles demanding space on those lanes.

The peak-flow configuration similarly provides higher speeds for buses and qualified car pools through use of an exclusive lane on the boulevard. However, because the exclusive lane has been preempted from one of the four peak-flow lanes this exclusive lane necessarily increases traffic density and lowers traffic speed on the remaining three peak-flow lanes.

Between the Ben Franklin Bridge Plaza and the Philadelphia CBD, the bridge has seven lanes, one of which is always kept empty to separate directional traffic. For maximum flow the Ben Franklin Bridge provides four lanes in the peak direction and two lanes in the contraflow direction. Within this framework, the bridges' four peak-flow lanes become three peak-flow lanes and one exclusive bus and car-pool lane when either configuration is being used. Existing bridge traffic speed must, therefore, marginally decrease because of decreased capacity.

Obviously, the differences between present conditions and the alternative configurations must result in changes in modal travel time. The travel times by each mode for each interchange were calculated and, with all other variables held constant, the model was rerun for each of the modal pairings for each alternative case.

ANALYSIS OF MODAL SHIFTS

The model indicated that there were diversions from automobile to bus, from automobile to car pool, from automobile to high-speed line, and even from high-speed line to bus and car pool.

The results of applying the model indicate that the implementation of an exclusive bus and car-pool lane would yield nearly identical exclusive lane use (approximately 10 500 person trips in the morning peak period) whether the lane were contraflow or peak flow. This yield represents an approximate 13 percent increase in bus plus car-pool demand.

Although the high-speed line now carries slightly over 51 percent of the market, implementation of either exclusive bus and car-pool lane alternative would only drop the high-speed line's share to 50 percent.

The analysis shows that the automobile mode would suffer the greatest intrusion on its market share (2.3 percent and 3.2 percent for the contraflow and peak-flow alternatives respectively). The corresponding losses for the high-speed line would be 2.1 percent and 1.3 percent respectively.

Figure 1. Marginal shifts in modal demands.

ALTERNATIVE	AUTO	BUS/CARPOOL	HIGH-SPEED LINE
CONTRA-FLOW	(651) →	→ 1,240 ←	← (589)
	651 Net Loss	1,240 Net Gain	589 Net Loss
PEAK-FLOW	(239) → (675) →	→ 1,264 ←	→ 239 ← (589)
	914 Net Loss	1,264 Net Gain	350 Net Loss

Although these net modal gains and losses are of primary interest to this study, isolating the various intermodal marginal shifts that resulted in these net changes is also important. Figure 1 reveals that the high-speed line loses an equal number of persons to the exclusive lane under either alternative. The automobile mode also loses nearly an equal number of persons to the exclusive lane under either alternative. The major difference between the two alternatives is that the peak-flow alternative causes an additional loss of 239 persons from automobile to high-speed line. This additional marginal shift is a direct result of the decreased vehicle capacity on the boulevard.

This study indicates that a car pool is the least significant travel mode in the corridor. Even the implementation of an exclusive bus and car-pool lane on a congested, but vital, arterial highway seems to have little real effect on boosting the market sharing of car pooling.

CONCLUSIONS

1. The implementation of an exclusive bus and car-pool lane on Admiral Wilson Boulevard and on the Ben Franklin Bridge would yield nearly identical use whether the lane is contraflow or peak flow.
2. If an exclusive lane is implemented, regardless of its configuration, it could result in a reduction of 1 to 2 percent of the Lindenwold High-Speed Line share of the total market.
3. Excluding car pooling, the automobile is the least significant mode in the market and would sustain the greatest intrusion into its share of the market (2.3 to 3.2 percent).
4. Implementation of an exclusive lane in the peak-flow direction would result in a loss of nearly three times as many riders from automobile as from high-speed line. The contraflow lane would result in a loss of almost equal numbers from both automobile and high-speed line.
5. The peak-flow alternative would cause a 40 percent greater shift from automobile than would occur in the contraflow alternative. However, this additional loss would be attracted to the high-speed line rather than to the exclusive bus and car-pool lane.
6. Car pool would be the least significant mode in the market area. The implementation of an exclusive lane might have little real effect in improving the market share of this mode.

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Abridgment

Simulation of a Bus-Priority Lane

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The use of bus-priority measures to increase to optimum highway flow of passengers, as opposed to highway flow of vehicles, is being applied in many developed countries. A review of the application of bus-priority measures has been made in the United States by the National Cooperative Highway Research Program (1) and in the United Kingdom by the Transport and Road Research Laboratory (2). This paper describes a simulation model of bus priority developed at the University of Bradford, England.

To assist the peak-hour tidal traffic flow into and out of the city of Bradford, West Yorkshire, England, a bus-only lane has been established on a section of the A-65 Bradford to Keighley highway.

The section of the Bradford to Keighley highway studied is a two-way, four-lane highway 1.1 km (0.7 mile) long and has three signal-controlled junctions. The highway carries bus flows in excess of 50 buses/h inbound in the morning peak period and in excess of 60 buses/h outbound in the evening peak period.

SIMULATION MODELS

In an investigation into the overall travel effects of this bus-priority scheme, two digital computer simulation models have been developed. The first simulates inbound traffic flow on the highway in the morning peak hour under normal nonpriority conditions; the second simulates traffic flow when bus-priority lanes are in operation.

In the nonpriority model the rules of operation of the model assign vehicles traveling straight ahead to the in-