DEDICATED LANE STRATEGIES FOR URBAN MOBILITY

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Abstract: The impacts that would result from providing "reserved capacity" for trucks rather than restricting trucks are considered in this paper. In the extreme case, trucks would be allowed to travel in a dedicated or exclusive lane. A more moderate approach would be to provide a "cooperative" dedicated lane in which vehicles such as trucks and buses could share a common lane and yet be separated from general traffic. The study determined the following. Reserved-capacity strategies for trucks would offer (1) nearly $10 million in annual travel time savings for the trucking industry, (2) a savings of about 2.5 minutes per average truck trip (less than 8 percent savings in trip travel time), and (3) almost $30 million in annual travel time savings for single-occupancy vehicles in the Seattle region. Surveys of the general public and subsequent statistical analysis showed considerable resistance to reserved-capacity strategies for trucks. However, this resistance is not unlike that encountered when HOV lanes were first considered. It is the recommendation of this paper that the idea of lane management strategies for trucks continue to be presented to the trucking industry, to the public, and to other impacted agencies for discussion and consideration. The study showed that the adverse impacts of such strategies are easily manageable and there is at least potential for freight-productivity improvements.

Key Words: Freight Mobility, Dedicated Lane Strategy, Reserved Capacity Strategy, Ordered Probit

1. INTRODUCTION

Several studies have explored ways to improve urban congestion by focusing on truck travel. In particular, strategies for improving urban congestion have investigated limiting truck travel by restricting lanes, routes, or time of day. These strategies are based on the perceptions that large trucks (1) restrict motorists' vision because of their size, (2) threaten safety because of slow braking capabilities, and (3) delay motorists because of slow accelerations and an inability to maintain speed on upgrades. However, given that large trucks typically make up less than 5 percent of the average daily traffic (ADT) in urban areas (BST Associates, 1991), perhaps a disproportionate amount of effort is being spent on restricting large truck travel. Instead, perhaps attention should be redirected toward improving freight productivity by minimizing the impacts of urban congestion on the trucking industry.

Many of the current improvement strategies, both restrictive (lane, route, time of day) and non-restrictive (changed hours of operation, changed routes), were developed under the same premise: truck operations are most efficient when trucks are separated (either physically or by time of day) from general traffic. Perceived benefits include (1) improved safety, (2) reduced incident impacts, (3) increased capacity, and (4) less fuel consumption and better air quality.
Studies have considered the impacts to both the trucking industry and general traffic in implementing restrictive strategies. However, little work has been done to determine the impacts that would result from non-restrictive strategies that allowed the trucking industry special travel benefits.

The impacts that would result from providing "reserved capacity" for trucks are of particular interest. Adequate capacity could be guaranteed for trucks, eliminating their need to compete with the general traffic. Several variations of lane usage exist. In the extreme case, trucks would be allowed to travel in a dedicated or exclusive lane. Vehicles other than trucks would be restricted from using this lane. The exclusive truck lane could be operated continuously throughout the day or during peak congested periods (i.e., the lane would be reserved for truck travel during the peak periods but would be open to general traffic at other times of the day). A more moderate approach would be to provide a "cooperative" dedicated lane in which vehicles of different modes could share a common lane and yet be separated from general traffic. Private trucking firms could support the development of a cooperative dedicated lane by paying a per-use toll, as suggested in the congestion-pricing scheme. While not limited to trucks, the congestion-pricing scheme considers the "sale" of excess capacity in the high occupancy vehicle (HOV) lanes to motorists willing to pay a fee to avoid congestion.

This paper provides a set of quantified estimates of how various changes in the distribution of truck traffic would impact facility operation throughout the Seattle urban area.

2. LITERATURE REVIEW

A shared HOV lane is a lane that is reserved for buses, carpools or vanpools, and large trucks. A bus/truck lane is a lane reserved for large trucks and buses only. Trucks and buses share many of the same characteristics, which make the idea of allowing trucks to utilize the HOV lane feasible. Literature pertaining to trucks in HOV lanes is limited. A study in Texas examined the impacts of joint truck and bus use of a limited access contraflow lane. The study concluded that a joint limited access contraflow lane should not be implemented because of low perceived trucking industry benefit (Holder, et al 1979). The reason cited was that the trucks needed to enter and exit the facility more often than was allowed. An international study, Cargo Routes: Truck Roads and Networks (Organisation for Economic Co-operation & Development (OECD) 1992), examined whether evidence is sufficient to justify the creation of dedicated lanes or a completely new road network for trucks. It concluded that "Truck-only lanes appear to be of limited value. Generally, it appears that they would reduce the operational flexibility of use of the road. Particular problems may arise where trucks try to overtake other trucks or where the road is heavily congested and the trucks are traveling faster than vehicles in the other lane(s)” (OECD 1992).

A truck-only lane may be viewed as not providing benefits because the general public would not be able to use them. More efficient transportation of food and goods is not clearly understood as a benefit by the general public. Cooperative truck-HOV lanes may receive the same public disapproval because trucks may be perceived as receiving special treatment. A 1979 study by R. J. Hansen and Associated Ltd., researched two options: (1) the addition of unreserved lanes, and (2) adding separate bus ways. The study concluded that adding unreserved lanes was the better cost effective improvement because of the high cost of adding separate roadways. The study also noted that for either of these options, passenger cars received 60 to 70 percent of the derived benefits. This indicates that the majority of benefit
Congestion is a concern on most urban freeways. Not only does congestion continue to increase annually, but truck volumes are also rising. The relationship between freight mobility and congestion is an important one because congestion reduces the efficiency of trucks and results in higher costs for moving goods. Most congestion management techniques point to truck restrictions of some sort, mainly by limiting hours of usage or limiting lane usage, and do not take into consideration economic effects. However, the **Regional Freight Mobility Action Packages** report developed for the Puget Sound Regional Council (Harvey Consultants Inc. 1994), clearly states that freight movement must be protected from policies that will restrict general purpose lanes, especially if general purpose lanes are being converted to HOV use. In fact, it suggests that selective freight be allowed access to HOV lanes if general purpose lanes are being taken away. Truck restrictions may actually increase what is perceived by motorists to be congestion. (Congestion is a function of vehicle speed and traffic volumes and not directly related to the distance between vehicles or headway.) Garber and Gadiraju concluded that restricting trucks to the right lane resulted in a decrease in vehicular headways in that lane. This decrease was significant on three-lane (one-direction) highways carrying AADT of greater than 75,000 and a truck proportion of greater than 3.6 percent and on two-lane (one-direction) highways with AADT of greater than 23,000 and a truck proportion of greater than 32 percent. (Gaber and Gadiraju 1990).

Truck safety is not directly related to freight mobility. However the impacts of the various freight mobility strategies on safety must be understood. When accidents do involve trucks, they tend to be more serious, and they include a higher share of fatalities (OECD 1992, Transportation Research Board 1989). Grenzeback et al (1990) concluded that "the volume of large trucks on the freeways does not have a significant effect on peak-period congestion but that truck-involved incidents and accidents do affect congestion significantly." Only when truck volumes exceed 10 percent is congestion affected by trucks (Grenzeback et al 1990). Roadway design is an important factor in many truck accidents. In general, the requirements for the HOV lanes meet truck design standards because the HOV lanes must accommodate buses.

The literature on freight mobility strategies does not provide encouraging results. Reserved lanes for trucks may not be cost effective or may have limited mobility value. In addition, the real benefits may be for the general public and not for freight operations. Congestion is the root of the freight mobility problem, and it creates a multitude of complications for large truck operators.

### 3. OPERATIONAL IMPACTS OF PROVIDING TRUCK PRIORITY LANES

The intent of this chapter is to evaluate the traffic-related impacts of freight-productivity improvement options in the Seattle area. Specifically, two lane management options will be evaluated: (1) a policy that permits heavy trucks (single-unit and tractor-trailer) to use high-occupancy vehicle (HOV) lanes and (2) a policy that adds a lane for the exclusive use of trucks on all facilities that have existing or planned HOV lanes. In evaluating these two options, we seek to determine their impact on the vehicle travel time and vehicle miles traveled by single-occupant vehicles (SOV), high occupancy vehicles (HOV), and heavy trucks.
3.1 Methodological Approach
To measure the impact of lane usage strategies in improving freight productivity, the traffic assignment program, a deterministic, macroscopic assignment program that is based on the user-equilibrium theory that states that all travelers will choose routes that minimize their travel times and user equilibrium will exist when no traveler can unilaterally improve his/her travel time by changing routes, was developed. The network defined for this analysis consisted of 1002 directional links, 277 nodes, and 30 origin and destination zones. Because truck origin-destination (O-D) data were not available, a systematic iterative approach was adopted in which a truck O-D matrix was assumed and the truck flows associated with this matrix (as estimated by the traffic model) were compared to actual observed truck flows. If estimated truck flows deviated from observed truck flows, the O-D matrix was revised and the process was repeated until model-estimated and observed truck flows were virtually identical. Socio-economic data were also used in approximating the truck O-D matrix by giving information on areas of high commercial and industrial activity. This information was used in updating the O-D matrix from one iteration to the next. It must be noted that this iterative procedure does not produce a unique solution. That is, in theory, there are many different O-D matrices that can produce the same observed truck flows. However, our approach of using the single-occupant O-D matrix along with census data on economic activity gives us some confidence that our constructed truck O-D matrix is close to the actual truck O-D matrix.

The traffic indicated in these three matrices was assigned sequentially. A simultaneous assignment is not mathematically possible within and the traffic assignment model and may not be realistic due to the link choices that are made by HOVs while in route. It seemed natural that the simulation-running sequence should be SOVs, HOVs, and trucks. SOVs do not have choices with regard to HOV lanes so they are a natural to be assigned first. HOVs can decide to take HOV lanes in response to observed congestion on the general purpose lanes and thus can respond to observed SOV traffic flows. Finally, trucks are assigned last because they are able to respond to observed SOV and HOV flows.

3.2 Simulation of Reserved Capacity Strategies
The impacts of allowing heavy trucks to use HOV lanes in the Seattle area (with passenger cars and buses) was estimated using the calibrated traffic assignment model. Table 1 gives a summary of the results and Figure 1 gives the percentage changes in travel times.

<table>
<thead>
<tr>
<th></th>
<th>Trucks using general-purpose lanes only</th>
<th>Trucks permitted in HOV lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOV Travel Times (veh-hrs)</td>
<td>170680</td>
<td>168260</td>
</tr>
<tr>
<td>HOV Travel Times (veh-hrs)</td>
<td>4389.5</td>
<td>4406.6</td>
</tr>
<tr>
<td>Truck Travel Times (veh-hrs)</td>
<td>5154.5</td>
<td>4758.7</td>
</tr>
<tr>
<td>Total Travel Time (veh-hrs)</td>
<td>180230</td>
<td>177430</td>
</tr>
<tr>
<td>Total Vehicle Miles of Travel</td>
<td>1808496</td>
<td>1810906</td>
</tr>
</tbody>
</table>

Table 1 shows that allowing trucks to use the HOV lanes saves single-occupant vehicles 2420 vehicle-hours during the morning peak hour while costing high-occupancy vehicles only 17.1 vehicle hours. If the vehicle occupancy of HOVs is estimated at 4, this policy produces savings of 2351.6 person-hours during the morning peak hour. If it is further assumed that morning and afternoon peaks last about three hours with approximately the same impact, the
savings is 14,109.6 person-hours per day (2351.6 × 6, conservatively ignoring possible benefits during off-peak periods). With about 260 work days per year, this gives 3,668,496 person-hours saved. Using a value of time of 8 dollars per hour, the saving is 29,347,968 dollars per year. Savings in truck travel time are 395.8 vehicle-hours during the morning peak hour or approximately 617,448 (395.8 × 6 × 260) vehicle hours per year. With the American Trucking Association estimate of the value of truckers' time at 15.85 dollars per hour, this amounts to savings of 9,786,551 dollars per year. Although these potential savings seem significant, some caution should be exercised in interpreting these results. First, the actual per-trip savings are comparatively small. The average truck trip will save about 2.5 minutes, but it is questionable as to whether these savings can be translated into improved productivity. This is because 2.5 minutes may just be too small of an increment of time to be used productively by manufacturing inventory control and truck dispatching. Second, HOV lanes in the Seattle area are currently underutilized, and thus any policy that increases their use will have a comparatively large impact on total vehicle travel time (e.g., the almost 3.7 million person-hours saved per year). Thus the impact on non-truck travel is not necessarily an artifact of the truck reserve-capacity policy but merely an underlying characteristic of the highway system.

To be sure, an unmeasured possible benefit of allowing trucks to use the high-occupancy vehicle lanes is the potential reduction in the variance of trip travel times. For example, if an average trip travel time of 30 minutes, with a standard deviation of 20 minutes, can be reduced to an average trip travel time of 28 minutes, with a standard deviation of 5 minutes, the potential for significant productivity improvements may be present. Experiences with HOV travel times suggest that a reduction in variance does indeed occur when reserved capacity is provided. However, because a significant portion of the trip is on streets without exclusive-HOV facilities, the reduction in travel-time variance is likely to be small. While measuring the variance in trip travel times is beyond current traffic-assignment modeling, this is a factor that must be considered when interpreting the results present herein.

One might ask why truck-trip travel times decline by less than 8 percent when they are allowed to use the HOV lanes. The reason is that, on average, a comparatively small portion of the total truck-trip distance is on facilities that have HOV lanes. Many trips do not use

![Figure 1](image_url)

**Figure 1.** The Percent Change in Travel Times Resulting From Allowing Trucks to Use High-Occupancy Vehicle Lanes.
facilities with HOV lanes at all, and are only indirectly affected by the policy in that some trips may be diverted from the routes that they do use. Interstate trucks traveling through the Seattle region may have their entire trips on facilities with HOV lanes and thus could show larger reductions in travel time when allowed to use HOV lanes. A possible adverse consequence of allowing trucks to use the HOV lanes is that more trucks may be tempted to travel during peak periods, thus adding to existing traffic congestion. Finally, as expected, the total vehicle-miles traveled increases by 2,410 vehicle-miles (a mere 0.133 percent), as travelers are attracted to high-capacity facilities that offer lower travel times but slightly longer distances. Although politically and economically unlikely, the policy of constructing exclusive truck lanes (to be constructed everywhere HOV lanes exist or are planned) was assessed to provide an upper limit on the potential impacts of truck reserved-capacity alternatives.

Table 2 shows that constructing a truck-lane system to parallel the HOV-lane system produces results almost identical to the scenario that allowed trucks to use the HOV lane. When compared to the policy allowing trucks to use the HOV lanes, the exclusive truck lane saves only 90 single-occupant vehicle-hours, 10.1 high-occupant vehicle hours, and 7.8 truck-hours during the morning peak period. These small improvements reflect: (1) the comparatively small number of heavy trucks (i.e., small benefits from having their own lane), (2) the fact that many truck trips do not use facilities that have HOV-lanes (and thus truck-only lanes), and (3) the current underutilization of the HOV-lane system. The underutilization of the HOV-lane system makes the difference in travel time between the policy option that adds trucks to the existing HOV lanes and the policy option that adds an exclusive truck lane, insignificant, because allowing trucks in the HOV lane has minimal effects on HOV-lane congestion and travel times.

Table 2. Simulation Results Impacts of Exclusive Truck Lanes

<table>
<thead>
<tr>
<th></th>
<th>Trucks permitted in HOV lanes</th>
<th>Trucks using exclusive truck lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOV Travel Times (veh-hrs)</td>
<td>168260</td>
<td>168170</td>
</tr>
<tr>
<td>HOV Travel Times (veh-hrs)</td>
<td>4406.6</td>
<td>4396.5</td>
</tr>
<tr>
<td>Truck Travel Times (veh-hrs)</td>
<td>4758.7</td>
<td>4750.9</td>
</tr>
<tr>
<td>Total Travel Time (veh-hrs)</td>
<td>177430</td>
<td>177320</td>
</tr>
<tr>
<td>Total Vehicle Miles of Travel</td>
<td>1810906</td>
<td>1810700</td>
</tr>
</tbody>
</table>

The traffic simulation approach used in this study provides valuable information on the potential traffic-related impacts of two lane usage alternatives; one that permits heavy trucks to use HOV lanes and one that adds a lane for the exclusive use of trucks on all facilities that have existing or planned HOV lanes. Our findings suggest that significant travel-time savings are possible for single-occupant vehicles, but this is an artifact of the current underutilization of HOV lanes in the Seattle area and not necessarily a virtue of reserved-capacity alternatives. Our findings also show that the difference in travel times between the alternative that adds trucks to the existing HOV lanes and the alternative that adds an exclusive truck lane is insignificant, thus showing little need for the construction of an exclusive truck lane.

Finally, in interpreting the results presented in this chapter, it is important to recognize the limitations of the traffic simulation approach used. First, the truck origin-destination matrix had to be estimated. Although we are confident that our matrix is reasonably close to the true matrix, some caution must be used in interpreting the results. Second, our model assigns
travel on the basis of expected travel time and assumes that travelers do not change their trip-departure times or modes in response to congestion. The reserved-capacity alternatives considered herein would almost certainly have long-term effects on departure times and mode choices that would need to be considered before implementing the alternatives. Still, in spite of these limitations, the results presented in this chapter provide a good idea of the range of impacts that can be expected.

4. SURVEY ANALYSIS: OPINIONS OF PROVIDING TRUCK PRIORITY LANES

Negative public opinion is cited as the most important reason for not taking advantage of travel benefits. As an example, the California Transportation Department has allowed large trucks to use the HOV lanes on several urban freeways since 1992. Few trucks, however are taking advantage of the lane use privileges; recent large truck volumes in the HOV lane are less than 1 percent of the total HOV traffic. Enforcement agencies have expressed concerns regarding enforcement of truck mobility strategies. Another of their concerns is the possibility of more accidents involving large trucks if the facility would require them to make lane changes. Traditional mobility projects have been aimed at person movement. In spite of knowing that large trucks make up a relatively small proportion of traffic on urban freeways, they often emphasized restricting truck traffic. Traditionally, the general public has been opposed to changing the existing freeway lane configuration by reducing general purpose lane capacity.

This survey may lay the groundwork for freight mobility projects by allowing agencies to effectively educate various agencies and the general public. It will also allow agencies to forecast probable acceptance of freight mobility strategies in specific corridors once the socioeconomic and driving characteristics of the commuters are known.

4.1 Survey Methodology

Five separate surveys were developed, one for each target group -- (1) general public, (2) large truck operators, (3) truck companies, (4) bus drivers, and (5) traffic enforcement personnel. Each survey was divided into four sections: (1) driving characteristics, (2) preferences, (3) opinions, and (4) background. Each of the five surveys were not unique; a set of common questions were included in each of the five surveys for comparative purposes. Surveys were distributed to 1,885 general public drivers, 338 large truck operators, 150 truck company representatives, 200 bus drivers, and 148 traffic enforcement personnel (WSP).

4.2 Descriptive Statistics of Survey Results

The respondents were queried about their preferences for the freight mobility strategies (shown in Figure 2). The strategies for consideration were a truck-only lane, a truck/bus-only lane or a truck/HOV lane. The general public and WSP troopers clearly favored the truck and bus lane strategy, which is perhaps an indication that they perceive trucks and buses as similar in size and weight. Interestingly, the bus drivers preferred the truck only strategy, indicating that they do not want to be in the same lane as trucks. The truck companies and truck drivers appeared to slightly favor the truck-only and HOV/truck-only choices, indicating that sharing a lane with buses was their least favorite option.

Table 3 shows how respondents thought they would behave if large trucks were allowed into the HOV lanes. This question was not asked to the WSP troopers. This survey question produced interesting results when compared to a previous question that queried the general public respondent on their current HOV usage. For instance, 36 percent of the general public
stated that they frequently use HOV lanes, but this percentage drops significantly to only 11 percent if trucks were allowed into HOV lanes. On the flip side, 12 percent of the general public stated that they never currently use HOV lanes, and this percentage would rise dramatically to 49 percent if trucks were allowed into the HOV lanes. This is a clear indication that the general public does not want to be in the HOV lane with large trucks. It also appears that the truck companies were optimistic about how often their drivers would use the HOV lane; because the drivers would be the ones driving, their rate of use may be considered slightly more accurate.

The respondents’ preferences for which side of road the reserved lane or HOV/truck lane should be located are noted in Figure 3. Four of the five groups indicated a clear preference for a right-side reserved or HOV/truck lane. Only the truck drivers preferred to have the HOV lane on the left-side of the road, and this was only slightly more popular than their preference to locate them on either side of the roadway.

Table 3. Predicted HOV Lane Usage If Large Trucks Were Permitted

<table>
<thead>
<tr>
<th></th>
<th>General Public</th>
<th>Bus Driver</th>
<th>Truck Company</th>
<th>Truck Stop Driver</th>
<th>Safeway Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not use HOV</td>
<td>49%</td>
<td>38%</td>
<td>13%</td>
<td>14%</td>
<td>13%</td>
</tr>
<tr>
<td>Occasionally use HOV</td>
<td>35%</td>
<td>43%</td>
<td>28%</td>
<td>36%</td>
<td>36%</td>
</tr>
<tr>
<td>Frequently use HOV</td>
<td>11%</td>
<td>17%</td>
<td>55%</td>
<td>48%</td>
<td>45%</td>
</tr>
</tbody>
</table>

Responses to whether large trucks should be restricted by time of day from using the HOV lane or reserved lane are shown in Figure 4. Only WSP troopers preferred to not allow trucks into the lane at any time. The rest of the respondents preferred to allow them into the lane at all times. These answers indicate that all of the groups would prefer consistency, whether all or nothing, if a freight mobility option is implemented. The respondents rated all opinion section freight mobility questions similarly for safety and congestion. If a strategy was viewed as an improvement to safety, it was also viewed as a way to improve congestion.

Figure 2. Preference Rate for Various Freight Mobility Strategies (Lane-usage Alternatives)

Figure 5 illustrates how each responding group agreed with the statement that a freight mobility strategy would improve safety and congestion. As can be seen in the figure, there is general agreement among all but the WSP troopers that the truck-only lane would produce the most improvement in safety and congestion. The bus and truck-only lane strategy would be
next, followed by the HOV and truck lane strategy. The next question asked whether the respondents agreed or disagreed with the statement that trucks should be allowed to travel in the HOV lane only if they meet the occupancy requirement. Figure 6 shows that there was considerable agreement among all the respondents; they did not agree that trucks should be required to meet occupancy requirements to use an HOV lane. In other words, having two or more people in the truck should not be the reason they should be allowed into HOV lanes. This would be agreeable from the WSP viewpoint because it is difficult to count the number of occupants in a large truck and enforcement of the requirement would be difficult.

![Figure 3. Preference Rate for Various Lane Location Alternatives](image)

![Figure 4. Percent Preferring Restrictions on Lane-Usage Times](image)

![Figure 5. Percent Believing Various Lane Strategies Will Improve Safety and Congestion](image)

The last question asked respondents whether they agreed or disagreed with the statement that trucks should pay a special fee to use a reserved or existing HOV lane. The responses can be
seen in Figure 7. While truck drivers and truck companies clearly disagreed strongly with the statement, all of the other responding groups also disagreed more that they agreed. There was general agreement among all respondents that trucks should not pay additional fees to use a reserved or existing HOV lane. Currently, HOVs do not have to pay a fee to use the HOV lane. The majority of respondents from each group concurred that this same benefit should be given to large trucks if they are granted use of the lane.

Figure 6. Responses To The Statement: Trucks Should Be Allowed To Travel In HOV Lanes Only If They Meet Occupancy Requirements

Figure 7. Responses To The Statement: Trucks Should Pay A Special Usage Fee to Use A Reserved or Existing HOV Lane

4.3 Modeling Public Support of Truck Travel Benefits

An ordered probit model was developed to describe public response to the statement: *large trucks should have the same travel benefits as public transit and high occupancy vehicles.* Public response to this statement, more than any other information collected through the survey directly answers not how freight mobility should be improved but whether effort should even be made to improve freight mobility. The distribution of agreement with the statement that large trucks receive the same travel benefits as public transit and HOVs is shown in Figure 8. The majority of the general public (57 percent) disagreed in some form (disagrees or disagrees strongly) that large trucks should have the same travel benefits as HOVs and transit.

An ordered probability model was appropriate in this situation because agreement ratings are discrete ordered responses, not continuous non-integers such as those handled by ordinary least squares regression. Ordered probability models account for the order of the responses; they account for the fact that “agree strongly” is of greater importance than the “agree” choice. Standard multinomial probability models do not take into account the order
relationship between choices, thereby making ordered probability models potentially more accurate with discrete data that are ordered. For our ordered probability model, the unobserved variable \( z \) was used to define the predicted agreement rating choice by a respondent. The unobserved variable is specified as:

\[
z = \beta X + \varepsilon,
\]

where \( X \) is a vector of characteristics determining the respondents' chosen agreement rating, \( \beta \) is a vector of estimable parameters, and \( \varepsilon \) is a random disturbance term. Using this equation, observed agreement rating choices, \( y \), are defined as:

\[
y = 0 \quad \text{if } z < \mu_0,
= 1 \quad \text{if } \mu_0 < z < \mu_1,
= 2 \quad \text{if } \mu_1 < z < \mu_2,
= \ldots
= 5 \quad \text{if } z > \mu_4
\]

where \( \mu_s \) are free estimable parameters that define \( y \), and values of \( y \) (e.g., 0, 1, 2) correspond to agreement rating categories (i.e., disagree strongly, disagree, neutral, agree, and agree strongly). Note that without loss of generality, \( \mu_0 \) can be scaled to zero. Because the disturbance term \( \varepsilon \) in equation (1) follows a standard normal distribution (with mean = 0 and variance = 1), an ordered probit model results.

![Figure 8. Responses To The Statement: Large Trucks Should Have The Same Travel Benefits As Public Transit And HOVs](image)

4.4 Results of Probit Model Estimation
The model identified the population characteristics that could be targeted for public education should freight mobility strategies prove promising. Table 4 provides the estimated coefficients and t-statistics for the probit model.

Variable: Number of licensed motor vehicles owned
The negative coefficient indicates that as the number of licensed vehicles residing in the household increased, the likelihood that the respondent disagreed or strongly disagreed with the statement that trucks should have the same travel benefits as HOVs also increased. Multiple vehicles within a household indicates that more than one licensed driver may live there. If a vehicle is readily accessible, there is a reduced incentive to carpool or use transit. Allowing trucks into the HOV lane may be perceived as encouraging higher volumes of trucks during congestion periods, a situation that would not be advantageous for someone who frequently used the freeways. In addition, allowing trucks into the HOV lane could displace HOV users to the general purpose lanes, a situation that would for them lower

capacity in those lanes.

Table 4. Ordered Probit Model Describing Public Support of Truck Travel Benefits

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimated Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.66</td>
<td>1.51</td>
</tr>
<tr>
<td>Number of licensed vehicles in household</td>
<td>-0.19</td>
<td>-1.86</td>
</tr>
<tr>
<td>Over 2 licensed vehicles (1 if household has 3 or more licensed vehicles, 0 otherwise)</td>
<td>0.26</td>
<td>1.11</td>
</tr>
<tr>
<td>Age category (increased as respondent age increased, varied between 1 and 12 (oldest))</td>
<td>0.03</td>
<td>2.30</td>
</tr>
<tr>
<td>Number of years owned drivers</td>
<td>-0.04</td>
<td>-2.50</td>
</tr>
<tr>
<td>HOV policy awareness (1 if knew that trucks weren’t allowed in HOV lane, 0 otherwise)</td>
<td>-0.27</td>
<td>-1.86</td>
</tr>
<tr>
<td>Gender (1 if male, 0 otherwise)</td>
<td>-0.19</td>
<td>-1.32</td>
</tr>
<tr>
<td>HOV policy (1 if HOV policy should be changed to allow trucks, 0 otherwise)</td>
<td>0.66</td>
<td>3.45</td>
</tr>
<tr>
<td>Household income (1 if annual income is $40,000 - $59,999, 0 otherwise)</td>
<td>0.21</td>
<td>1.24</td>
</tr>
<tr>
<td>Household income (1 if annual income is greater than $75,000, 0 otherwise)</td>
<td>-0.30</td>
<td>-1.84</td>
</tr>
<tr>
<td>SOV (1 if drive alone, 0 otherwise)</td>
<td>0.19</td>
<td>1.29</td>
</tr>
<tr>
<td>No HOV use with trucks (1 if they would not use HOV lane with trucks, 0 otherwise)</td>
<td>-0.40</td>
<td>-2.90</td>
</tr>
<tr>
<td>Trucks are vital to economy (1 if they agreed with statement, 0 otherwise)</td>
<td>0.66</td>
<td>3.47</td>
</tr>
<tr>
<td>Household size (1 if there are more than 2 persons in household, 0 otherwise)</td>
<td>0.23</td>
<td>1.62</td>
</tr>
<tr>
<td>Comment (1 if pro-truck comment, 0 otherwise)</td>
<td>0.49</td>
<td>1.45</td>
</tr>
<tr>
<td>Comment (1 if anti-truck comment, 0 otherwise)</td>
<td>-0.77</td>
<td>-4.67</td>
</tr>
<tr>
<td>Education (1 if they have had some college or university education, 0 otherwise)</td>
<td>-0.24</td>
<td>-1.58</td>
</tr>
<tr>
<td>HOV use (1 if never uses HOV lane, 0 otherwise)</td>
<td>0.44</td>
<td>2.11</td>
</tr>
</tbody>
</table>

Initial Log-likelihood: -536.66
Log-likelihood at convergence: -387.86
Corrected $\rho^2$: 0.26

Variable: More than two licensed vehicles in household
Unlike its counterpart variable, *Number of licensed motor vehicles owned*, this variable was not multiplied by the number of vehicles owned and was included only once if a person met the criteria. This variable tempers the results of its counterpart variable by suggesting that not all people who own several vehicles are opposed to trucks having the same travel benefits as HOVs and transit. Because this variable’s coefficient was almost the same magnitude as that
of its counterpart, its effect was to essentially cancel out one of the many vehicles owned by the respondent.

Variable: Age of respondent
The positive coefficient indicates that older respondents were more likely to agree or strongly agree with the statement that trucks should have the same travel benefits as HOVs than younger respondents. This variable contrasts sharply with its counterpart variable, Number of years owning a drivers license, which had a negative coefficient. Both variables were similar in weight, this variable had a coefficient of 0.03, and the counterpart’s coefficient was a – 0.04. Assuming that most people receive their driver’s license at 16 years old, this variable in the average respondent’s model would be 16 times 0.03, or a total of 0.48 greater than the counterpart variable. A respondent would have to own a driver’s license for 48 years before the negative coefficient weighting of their model’s counterpart variable would cancel out all of this variable’s positive coefficient weight. Therefore, people 64 years or older would be most likely to support freight mobility strategies. The highest model positive coefficient weighting would be obtained for respondents who did not receive their driver’s license until much later in life.

Variable: Aware that trucks are not allowed in Washington State HOV lanes
The negative coefficient indicates that if a respondent knew that trucks are not allowed in HOV lanes within Washington State, he or she was likely to disagree or disagree strongly with the statement that trucks should have the same travel benefits as HOVs. Conversely, if the general public respondent was not aware of the law, he or she was more likely to respond that trucks should have the same travel benefit as HOVs. Nearly one-third of the respondents knew that trucks are not currently allowed in the HOV lane. These people were familiar with the regulations on the freeways, perhaps they did more driving and lived in areas where they could access HOV lanes. It makes sense that respondents who utilized the HOV lanes would not be receptive to regulations that would take away from the advantages that they receive by using them. For example, allowing trucks into the HOV lane may be perceived as a reduction of their current HOV benefits.

Variable: Gender
The negative coefficient indicates that if a respondent was male, he was likely to disagree or disagree strongly with the statement that trucks should have the same travel benefits as HOVs. Men are typically more competitive by nature and like to take more risks (risk in this context being driving faster) than females. If trucks use the HOV lanes, then men may perceive them as receiving a travel advantage that they did not earn and as possibly slowing down the HOV lane travel speed – both of which are disagreeable.

Variable: Prefer HOV policy changed to allow trucks
The positive coefficient indicates that if a respondent preferred changing the HOV policy to allow trucks over all other freight mobility strategies, they were likely to agree or agree strongly with the statement that trucks should have the same travel benefits as HOVs. These respondents already showed sympathy toward allowing trucks into the HOV lane, so their agreement with the statement that trucks should have the same travel benefits as HOVs and transit was not surprising.

Variable: Household income
The positive coefficient indicates that if a respondent lived in a household that earned between $40,000 and $59,999, they were likely to agree or agree strongly with the statement...
that trucks should have the same travel benefits as HOVs. It is likely that this income bracket contains people whose lifestyles and jobs are sensitive to the trucking industry. The negative coefficient indicates that if a respondent lived in a household that earned equal to or greater than $75,000, they were likely to disagree or disagree strongly with the statement that trucks should have the same travel benefits as HOVs. These respondents are typically financially secure, they do not need to carpool or take the bus, they can afford to drive their own cars. Although they may realize the importance of the trucking industry, they may be less sensitive to cost increases resulting from inefficient goods movement.

Variable: Usually drives alone
The positive coefficient indicates that if a respondent usually drove alone, he or she was more likely to agree or agree strongly with the statement that trucks should have the same travel benefits as HOVs. Because allowing trucks the same travel benefits as HOVs would result in additional general purpose capacity, perhaps moving trucks to the HOV lane makes sense for the respondent who usually drives alone.

Variable: Would not use the HOV lane with trucks
This variable acts as expected, in that the respondent has already indicated opposition to trucks. They do not perceive that the HOV lanes would still provide travel benefits if trucks began using them.

Variable: Trucks are vital to the economy
The positive coefficient indicates that if a respondent felt that trucks are vital to the economy, they were likely to agree or agree strongly with the statement that trucks should have the same travel benefits as HOVs. These respondents realize that trucks are important to the delivery of the consumer goods they use every day. Allowing trucks the same travel benefits as HOVs and transit is perceived as a way of keeping the economy running smoothly.

Variable: More than two persons in household
The positive coefficient indicates that if more than two people lived in the respondent’s household, they were likely to agree or agree strongly with the statement that trucks should have the same travel benefits as HOVs. Carpools can be easily formed in larger households, e.g., you could commute to work with a housemate, go shopping, or go on trips. It appears that this group should be in disagreement with the statement because allowing trucks the same travel benefits may reduce HOV capacity. The answer may be that this group perceives trucks as being non-threatening to their current HOV travel benefits. In addition, larger households use greater amounts of truck delivered consumer goods, so they may better appreciate the importance of trucks to the economy.

Variable: Comment
The negative coefficient indicates that if a respondent gave a negative freight mobility comment on their survey, he or she was more likely to disagree or disagree strongly with the statement that trucks should have the same travel benefits as HOVs. We would expect someone who spoke negatively about freight mobility to disagree that trucks should enjoy any increase in travel benefits. The positive coefficient indicates that if a respondent gave a positive freight mobility comment on their survey, he or she was more likely to agree or agree strongly with the statement that trucks should have the same travel benefits as HOVs.

Variable: College or university educated
The negative coefficient indicates that if a respondent had received a college or university
education, he or she was more likely to disagree or disagree strongly with the statement that
trucks should have the same travel benefits as HOVs. Highly-educated people may be more
likely to understand the principles behind HOV lanes. Trucks would reduce the HOV
capacity and travel benefits, hence the negative response.

Variable: Never use HOV lane
The positive coefficient indicates that if a respondent never uses the HOV lane, he or she was
more likely to agree or agree strongly with the statement that trucks should have the same
travel benefits as HOVs. Considering that these respondents do not use the HOV lane, they
most likely do not care about its fate. This group may perceive that the majority of trucks will
move into the HOV lane increasing capacity in the general purpose lanes for themselves.

6. CONCLUSIONS AND RECOMMENDATIONS

The study determined that reserved-capacity strategies for trucks would offer nearly $10
million in annual travel time savings for the trucking industry in the Seattle region. Although
this is not a large amount in relation to the amount of truck activity in the area, it is still a
sizable savings. In terms of truck-industry productivity, the impact of reserved-capacity
strategies on individual trips would be small, about 2.5 minutes saved per average trip (less
than 8 percent savings in trip travel time). Although it is unlikely that trucking firms could
effectively use such a small savings in travel time to improve productivity, it is possible that
some trucking operations could benefit, particularly those whose trucks would spend large
portion of their trip on facilities with reserved capacity. In addition, the potential reduction in
the variance of travel-time could help the trucking industry. However, whether the trucking
industry would be able to take advantage of the average 2 to 3-minute reduction in trip times
and the reduction in travel-time variance remains unknown. The biggest impact of truck
reserved capacity strategies is the travel-time savings they would create for single-occupancy
vehicles, almost $30 million in travel time saved per year. (Note that this is not an unusually
large number in comparison to the $250 million annual travel-time loss in the Seattle area due
to delays resulting from freeway incidents (Jones, Janssen, and Mannering, 1991). This
travel-time savings would be an artifact of the current under-utilization of HOV lanes in the
Seattle area and not necessarily a virtue of reserved-capacity strategies. Still, this result must
be weighed in any policy implementation. The study also determined that the difference in
travel times between the reserved-capacity strategy that would add trucks to the existing HOV
lanes and the one that would add an exclusive truck lane would be insignificant, revealing
little justification for the construction of an exclusive truck lane. Future growth in HOV and
truck traffic may result in congested reserved lanes and reduced truck travel time savings.

The most significant obstacle to reserved-lane capacities would be public opinion. Our
surveys of the general public and subsequent statistical analysis showed considerable
resistance to reserved-capacity strategies for trucks. However, this resistance is not unlike
that encountered when HOV lanes were first considered. As a result, one would expect that
careful marketing and resolve on the behalf of the implementing agency could persuade the
public to accept reserved-capacity strategies for trucks.

In conclusion, although there are many factors to consider, one key concern is whether the
trucking industry could take advantage of reductions in travel time and travel time variance
that would result from the implementation of a reserved-capacity strategy for trucks. This is a
difficult question to answer and one our surveys suggested that the trucking industry itself can
not answer. It is the recommendation of this study that the idea of reserved-capacity strategies for trucks continue to be presented to the trucking industry, to the public, and to other impacted agencies for discussion and consideration

REFERENCES


Harvey Consultants, Inc., Transmode Consultants, Inc. and Ellen Kret Porter (1994) *Regional Freight Mobility Action Packages*, developed with the Regional Freight Mobility Roundtable, Puget Sound Regional Council, Seattle, WA

Holder, R.W., D.L. Christiansen, C.A. Fuhs and G.B. Dresser (1979) *Truck Utilization of the 145N Contraflow Lane in Houston*, *Research Report 205-6*, Texas Transportation Institute, College Station, Texas

