On The Completeness of Survey Data for Carpool Performance Evaluation

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This paper addresses the issue of properly interpreting carpool survey data and the need to have a model to guide the survey and its interpretation. A model is developed. Unfortunately, for those that might think the problem simple, there are a significant number of variables (10) that must be determined by any survey. It concludes with a minimal set of survey questions required to conduct a proper analysis of the data.

INTRODUCTION

Various sources attempt to study the characteristics of High Occupancy Vehicle Lanes (HOVL) and carpools by means of survey data. These surveys question carpool participants to determine who carpools and why and draw conclusions about the number, motivation and incentives for promoting carpooling. Of particular importance to survey takers is the effectiveness of HOV priority lanes in causing travelers to rideshare. Statistics such as, "60 percent of HOVL users previously drove alone", and " 70 percent indicated the availability of an HOVL was a factor" seem to support arguments that HOVL are effective in carpool generation. As discussed below such conclusions are not necessarily correct.

Surveys also consistently show that carpool are not permanent structures but rather carpool formation and termination is very dynamic. Most surveys indicate that the average life span of a carpool arrangement is about 30 months. Life-span is time from the formation to the termination of a carpool. After termination the participants will either drive alone or form or join another carpool. In Houston, average life-span of 3 to 13 months was reported. While this dynamic is reported in many surveys, it is then ignored in the analysis and interpretation of the data.

An understanding of the implications of this dynamic can only be achieved if a model of the carpooling process is developed. The model will not only provide a means to interpret the data but will also provide incite into the scope and relevant information questions to ask in the survey. Without a decent model the surveyors are flying blind and end up generating interesting but meaningless data. It's like taking temperature measurements of the atmosphere without a weather model to predict rain. The weather model shows that pressure and wind measurements are needed also and then provides the prediction method. The following is a first attempt at development of such a model for carpooling (a much simpler process than weather).

MODEL DESCRIPTION

We start with some definitions. At any point in time travelers are divided into two groups, carpoolers and drive-alone. We will for now ignore transit riders and non powered (bicycle and walkers) travelers.

ND = number of drive-alone,

NC = number of carpoolers,
ρc = fraction of total carpooling,
ρd = fraction of total drive-alone,

Then the fraction of drive-alone and carpoolers is related by;

$\rho d = 1 - \rho c$.

The lifetime of a carpool is characterized by the average lifetime, Lc, and assuming a constant termination rate, λc. where,

λc = fraction of carpools terminating per unit time.

The relationship between λc and Lc is given by,

$Lc = 1/ \lambda c$.

During any interval in time ΔT, there will be $\rho c * \lambda c * \Delta T$ carpools terminating. The participants will either;

1) immediately get into another carpool,
2) become a temporary drive-alone looking for another carpool,
3) become a "permanent" drive-alone or,
4) stop being a traveler.

The latter case may be a worker who lost a job or a mother/ child to school combination with school ending. As we are dealing with a large population of travelers, others joining the population will offset such cases. However, because of surveying techniques we may want to identify these separately. In most cases there are more new drivers adding to the population than the reverse.

For an ex-carpooler looking for a new carpool there is a generation rate, λdt, for forming or joining an existing pool. This rate, λdt, is likely not to be the same as λc (but is not usually reported). The average lifetime of such a temporary drive-alone is symbolized as Ldt. Additionally, a terminating carpooler that finds an immediate new carpool (case 1 above) can be treated as a special case of case 2 above by an adjustment to λdt and Ldt. Here case 1 is assumed as part of case 2. The model must also account for the fraction of terminating carpoolers that transition into a new carpool as compared to becoming drive-alone travelers. For terminating carpoolers,

ρcc = fraction of terminating carpoolers that plan to transition into another carpool.

Lastly we must account for new carpools formed from ordinary drive-alone travelers and new travelers adding to the population or old travelers leaving the population of either drive-alone or carpools. For drive-alone conversions there will be a conversion rate,

λdc = fraction of drive-alone travelers converting to carpools per unit time.

New travelers will enter the population at a rate of λN and will enter as carpoolers at a rate, ρcn. Old travelers will exit the population at a rate of λE and will be distributed as ρce carpoolers and ρde drive-alone where,

$\rho de = 1 - \rho ce$.

Old drivers exiting the carpool group are however part of the carpool termination rate, λc. To account for this without double counting we define the terminating carpoolers to be divided as follows,

ρcc = fraction of terminating carpoolers that plan to transition into another carpool.
ρcex = fraction of terminating carpoolers exiting the system
ρcd = fraction of terminating carpoolers that will become "permanent" drive-alone (i.e. no immediate plans to join another carpool).

The variables are related as follows,

$\rho cc + \rho cex + \rho cd = 1$,
expressing the sum of the parts equals the whole,

$\lambda E * \rho ce = \lambda c * Nc * \rho cex$,
relating the exiting carpoolers in terms of the carpool termination model and rate,

If λN is the rate of new travelers, and their distribution is the same as existing travelers, then in an time period there will be $\lambda N * \Delta T * \rho c$ new carpools and $\lambda N * \Delta T * \rho d$ new drive-alone. This addition would impact the size of the population but not the distribution between carpools and drive-alone. However, it would impact a survey that asks what mode was used previous to the present mode.

As we can see, there are a significant number of independent variables in this model; ten to be exact. They are;

ND, λdc,
NC, λc, λdt, ρcc,
λN, ρcn,
λE, ρce.

The other variables described above can be derived from this set. Conversely, other sets of ten variables may be selected. Unfortunately, ten variables are a very large number to attempt to ascertain from a typical survey. Various simplifying assumptions will likely be made. However, while not fully satisfactory, explicitly making and understanding the assumptions is still better than not being aware of their existence as is now done.

EXPLORING THE MODEL

In this section some assumptions will be made for the purpose of exploring the significance of the model. In particular we will assume no new or exiting travelers and we assume all terminating carpools looking for a new carpool do so immediately. This can be expressed as,

$\lambda N = \lambda E = \lambda c = 0.$

Thus,
ND + NC = Ntotal = constant,
and we can just express the behavior in fractions. By doing so we can write the equation for the change in fraction of carpools with time as,

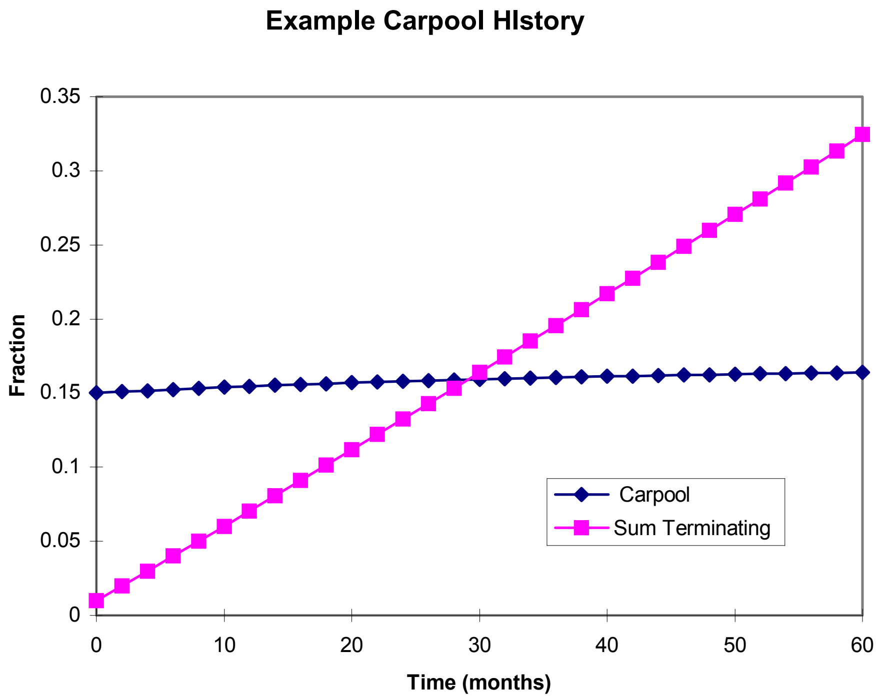
$$\rho c2 = \rho c1 - \rho c1 * \lambda c * \Delta T * (\rho cd) + (1 - \rho c1) * \lambda dc,$$

where the notation (1) refers to the conditions before the interval of time and (2) refers to after. The equation indicates that the fraction of carpools after ΔT is equal to the fraction before, minus those carpoolers converting too drive-alone, plus the drive-alone converting to carpools. Both conversions are seen to be driven by the carpool life-span parameter and the equivalent for the drive-alone.

As an example, consider the history of carpools in the following case;

$\rho c0 =$ 0.15
$\lambda c =$ 0.033, (equivalent to Lc = 30 months),
$\rho cd =$ 0.5,
$\lambda dc =$ 0.006

The average carpool life-span is chosen as 30 months, as experienced in surveys and the initial carpool fraction is set at 15 percent, a typical value. Also it is assumed that a terminating carpooler is highly likely to stay as a carpooler (50%), 3.3 times the rate that the average traveler chooses. We attempted to match the reverse conversion of drive-alone to carpools by adjusting λdc. The results are shown below.



The chart shows that the carpool fraction climbed by about one percent in the 60 month period. Also shown is the fraction of terminations (approximately equal to turnovers) of carpools in the period. There were about twice as many terminations as there was average carpools, or in other words, on the average, each carpool turned over twice. After 60 months only 13 percent of the carpools were from the original set. While not shown, of the carpools formed 62 percent came from drive-alone while only 38 percent were from terminating carpools. This despite the fact that the carpool retention factor, ρcd, was 50 percent and the growth in fraction carpools was only one percent.

While this is a somewhat arbitrary example, it illustrates the fact that large fractions of carpools formed from drive-alone do not necessarily mean carpool growth or the existence of growth incentives.

SURVEY GUIDELINES

The discussion above provides a first cut basis for interpreting carpool related surveys. It also indicates the need to collect certain information when conducting a survey. The following is an attempt to define a set of questions that would provide a complete set of data.

Of absolutely primary importance to properly understanding carpool behavior is the need to survey not only current carpoolers, but also drive-alone travelers. Also needed is information on past travelers that recently stopped commuting. It is unfortunate that those participants may be very difficult to identify and reach in a survey.

Candidate Questions

General
1) How long have you been commuting in this area?
2) What kind of a commuter are you? work, school, other?
3) Do you have a car available to you? Dedicated car, shared?
4) Are you the driver or a passenger?

Section A
A1) Are you currently commuting?
- If not go to section D

A2) Are you currently carpooling?
- If not were you a recent carpooler that is looking for new carpool?
  - If yes go to Section B.
  - If not go to Section C.

A3) How long has the carpool been in existence?
A4) Were you:
a) in a carpool just before this one?
b) driving alone?
c) driving alone as a temporary situation because of an earlier carpool ending?
d) a new driver in the area?

A5) How long did it take from the time you wanted to carpool to the time this carpool started.
A6) Why are you carpooling? (provide a list of factors).
A7) How much;
- Travel time does carpooling save?
- How much wait/ pickup time does it take?

Section B
B1) How long have you been looking for a carpool?
B2) How long was the previous carpool in existence?
B3) How long did it take from the time you wanted to carpool to the time that carpool started.
B6) Why are you carpooling? (list of factors to be provided).
B7) How much;
- Travel time did carpooling save?
- How much wait/ pickup time did it take?

Section C
C1) Were you in a carpool previously?
C2) How long had the carpool been in existence?
C3) When did it terminate?
C4) How long did it take from the time you wanted to carpool to the time that carpool started.
C5) Is carpooling an option for you? If not why?

Section D

D1) Why are you no longer a commuter in this area?
D2) How long did you commute in the area?
D3) Were you in a carpool previously? Drive-alone?
- What fraction of that time was in a carpool?

D4) How long had the carpool been in existence?
D5) When did it terminate?
D6) How long did it take from the time you wanted to carpool to the time that carpool started.
D7) How much;
- Travel time did carpooling save?
- How much wait/ pickup time did it take?