Fare pricing elasticity, subsidies and the demand for vanpool services

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Abstract

Transportation demand management practitioners consider pricing a crucial determinant of vanpool market demand. Publicly sponsored programs stress the significance of fare pricing and subsidies as key tools for increasing ridership. This paper investigates the effects of fares and fare subsidies on the demand for vanpool services. Using employer and employee data from the 1999 survey of the Commute Trip Reduction (CTR) program of the Puget Sound region (Washington), a conditional discrete choice model is built to analyze the choice of vanpool services with respect to competing means of transportation as a function of various socioeconomic characteristics. The predicted value of the direct elasticity is -0.73, indicating that vanpool demand is relatively inelastic with respect to fare changes. For trips below 30 miles, the individual elasticities are equivalent to the aggregate estimate. As the distance from home to work increases beyond 60 miles, individuals are less responsive to price changes. Subsidies have a relevant impact in increasing ridesharing, controlling for firm size and industry sector. Whenever employees are offered a subsidy, the predicted probability of choosing vanpool more than doubles. When considered in the context of subsidies, these results support the evidence that policies other than those intended to directly affect fare pricing, could play a relevant role in stimulating ridership.
Keywords: travel demand management, rideshare, vanpool, fare elasticity, fare subsidies, mode choice.

1 Introduction

Vanpooling is a travel mode that brings 5 to 15 commuters together in one vehicle, typically a van. As a mode of travel, public transit agencies report that vanpooling accounts for 0.4 % of total unlinked passenger trips, but 2.7% vehicle revenue miles [1]. In metropolitan areas with high occupancy vehicle lanes, vanpools are touted for their ability to bypass traffic jams, giving commuters potentially significant time savings.

Publicly sponsored vanpooling programs have been established since the late 1970's in response to the energy crises and have since experienced periods of surge and abandonment [2]. These programs are now a relevant component of transportation demand management (TDM) initiatives geared at reducing the negative impacts of congestion caused by more traditional modes of transportation, while promoting their use as an efficient and cost effective commuting alternative. Vanpool programs, in their promotional efforts, tend to overestimate the relevance of fare pricing as a means to increase ridership. At the same time, it is imperative for these programs to objectively assess the impact of fare pricing and subsidy policies to meet program goals and requirements.

In the literature, TDM research mostly has been concerned with evaluating the effectiveness of measures aimed at reducing solo driving. Its focus has been on strategies geared either at penalizing single occupancy vehicle (SOV) use, at providing incentives to use alternative modes, or at changing the time and frequency of trips. Several studies have examined the effects of incentives and disincentives on commuters' mode choice, concentrating their efforts in assessing the impact of pricing policies as a means of discouraging solo driving, often with contrasting results. For example, some suggest that free parking is considered as a major barrier to many worksite ridesharing programs [3], while others [4] conclude that commuter responses to parking pricing are less marked than previously inferred, suggesting a resistance to changes in solo driving behaviour in response to higher parking costs. Using a stated preference approach, Kuppam et al. [5] demonstrate that travel behaviour is affected by parking pricing, with trade-offs between transportation modes related to the commuter socio-demographic attributes and travel patterns.

Most of the studies that attempt to establish measures of price responsiveness with respect to mode shifts focus on transit ridership (for a comprehensive review of elasticity studies with a focus on transit, the reader is directed to TCRP Project H-6 Synthesis [6]). On the other hand, relatively few studies commissioned to assess specific vanpool programs have attempted to establish measures of price responsiveness as a means of promoting successful ridership programs [7]. In a more generic framework, while Ferguson [8] demonstrates that direct incentives to employees have the largest and most consistent impact among TDM pricing instruments, accounting for firm cohort and size, he does not model the impact of fares on rideshare.

The objective of this study is to empirically examine fare pricing responsiveness and the impact of subsidies on vanpool ridership. Using employer and employee data from the 1999 survey of the Commute Trip Reduction (CTR) program of the Puget Sound region (Washington), a conditional logit model was built to analyze vanpool choice with respect to competing means of transportation as a function of various socioeconomic characteristics.

Results indicate that vanpool demand is relatively inelastic with respect to fare changes. In particular, the direct elasticity of demand with respect to its fare is equal to -0.73, indicating a relatively low responsiveness to fare pricing changes. For example, a fare reduction of 10% is associated to an increase of 7.3% in demand. This is in contrast with a reported elasticity factor of -1.16 used in a previous study [7]. Furthermore, the sensitivity to price fare changes declines as the distance increases beyond 60 miles, as individuals become less responsive to price changes. Subsidies have a relevant effect in increasing ridesharing, accounting for firm size, and controlling for employee adherence to the CTR law and geographical heterogeneity. When a subsidy is offered, the odds of choosing vanpool over drive alone more than double. Firm size influences the likelihood of choosing vanpool as an alternative ridesharing mode. Results show that as firm size increases above 1,100 employees, the odds of choosing vanpool more than double, everything else constant. The negative impact of free parking on mode shift is more accentuated for employees working for large firms (above 2,600 employees).

The remainder of the paper is structured as follows. In Section 2, the sample survey dataset is analyzed and the proposed set of predictors is described. In Section 3, the approach to model building is outlined and the model is estimated. After the model is validated, results are discussed in Section 4. In Section 5 conclusions and caveats are considered.

2 Data description and analysis

The Puget Sound region has the largest vanpool fleet in the U.S., with six local vanpool operators providing more than 40% of the public vanpools in the country [9]. The dataset used to estimate the model was compiled from two separate surveys, the 1999 CTR program employee and employer surveys. Washington State adopted the CTR law in 1991 with the objective of improving air quality, reducing congestion, and decreasing dependence on petroleum fuels by instituting employer-based programs [10]. The law applies to employers with 100 or more full-time employees at a single worksite who are scheduled to begin their workdays between 6:00 and 9:00 a.m. weekdays and located in counties with populations of over 150,000 (Clark, King, Kitsap, Pierce, Snohomish, Spokane, Thurston, Whatcom, and Yakima counties). The purpose of this program is to encourage the use of alternatives to SOV for commuter trips as part of a comprehensive TDM strategy. Beginning in 1992, all employers participating in CTR programs began implementing surveys of their employees on a biannual basis to measure changes in commuting patterns. The purpose of the survey instrument is to track both employer programs and employee commute patterns to establish subsequent goals and measures geared at reaching program goals. The employee survey is a survey of revealed preferences (commuters are asked what their choice of transportation was in the week prior to the day being surveyed). The employer survey dataset provided information on mode-specific subsidy programs, as well as firm specific descriptors. This dataset provided quantitative and qualitative information on parking services and on subsidies on vanpools, carpool, and transit modes respectively.

Table 1: Vanpool mode choice predictors.

Variable	Mean	S.D.	Description
Mode	0.01	-	1 if Vanpool, 0 if Otherwise
DIST	14.54	11.55	Distance (one way) from home to work
DA_COST	2.64	2.74	Driving cost: $ per day
VP_COST	2.26	1.75	Vanpool cost: $ per day
CP_COST	1.96	2.04	Carpool cost: $ per day
TR_COST	2.12	0.48	Transit cost: $ per day
VP_SUB	0.40	-	Vanpool subsidy: 1 if Yes, 0 if Otherwise
CP_SUB	0.20	-	Carpool subsidy: 1 if Yes, 0 if Otherwise
TR_SUB	0.47	-	Transit subsidy: 1 if Yes, 0 if Otherwise
FDUM1	0.01	-	Firm size (employees): 1 if firm size greater than 1 and less or equal to 100, 0 if greater than 2600
FDUM2	0.24	-	Firm size (employees): 1 if firm size greater than 100 and less or equal to 280, 0 if greater than 2600
FDUM3	0.24	-	Firm size (employees): 1 if firm size greater than 280 and less or equal to 550, 0 if greater than 2600
FDUM4	0.25	-	Firm size (employees): 1 if firm size greater than 550 and less or equal to 1100, 0 if greater than 2600
FDUM5	0.19	-	Firm size (employees): 1 if firm size greater than 1100 and less or equal to 2600, 0 if greater than 2600
			Total Observations: 141,103

Table 2: Mode choice and vanpool subsidy.

Mode		Vanpool Subsidy		
		Yes	No	Total
Auto	Number	38,351	54,538	**92,889**
	Percent	41.29	58.71	65.83
Carpool	Number	8,571	12,769	**21,340**
	Percent	40.16	59.84	15.12
Vanpool	Number	1,565	920	**2,485**
	Percent	62.98	37.02	1.76
Transit	Number	6,210	11,328	**17,538**
	Percent	35.41	64.59	12.43
Other	Number	2,422	4,429	**6,851**
	Percent	35.35	64.65	4.86
Total Observations				**141,103**

Table 1 lists the most relevant variables tested in the model, while Table 2 displays information on the mode choice frequencies. After resizing the dataset to account for auto, carpool, vanpool, and transit, and after eliminating reporting errors, 141,103 observations were retained. The employees who chose vanpool as a means of transportation represent 1.76% of the sample, with 1,565 or 63% receiving some form of subsidy from their employers. This provides the first indication of the relevance of subsidy programs in influencing rideshare. Sample descriptive statistics showed that the daily cost of vanpooling ranges between $1.08 and $8.22, with a daily average of $2.26. The sample median distance across modes is about 12 miles, while for vanpool users it is about 25 miles, suggesting that vanpool users are more likely to have a longer journey to work.

3 Econometric model

The objective of this study was to build a model that could ultimately account for a set of relevant factors affecting the choice of vanpool as a mode of transportation with respect to the other modes being considered. Given that the choice set consists of two outcomes, an econometric modelling approach in the form of a discrete choice model was suggested. For overviews of discrete (binomial and multinomial) choice analysis, the reader is directed to Amemyia [13], McFadden [14], Blundell [15], and Domencich and McFadden [16].

The proposed equation is equivalent to the traditional conditional logit model (with error term assumed independent and from a Weibull distribution) is:

$$\Pr(y_{ji}) = \frac{e^{\beta x_{ji}}}{1 + e^{\beta x_{ji}}}$$

where: $\Pr(y_{ji})$ = probability that individual i chooses outcome j (vanpool).

Interest also lies in modelling the gradient or marginal effect, since it tells how choice probabilities change due to changes in the variables affecting choice. This paper makes use of marginal effects as well as the interpretation of estimated parameters of interest.

4 Results

The parameter estimates are showed in Table 3, with the relative standard errors and Wald Chi-Square statistics.

The estimated parameter associated with the vanpool fare (VP_VCOST), is statistically significant and its sign agrees with the theory of demand. Figure 1 shows the plots of the estimated cumulative distribution function (CDF) and the individual marginal effects interpreted at the means of the regressors.

The graph depicts the probability function (Probability Vanpool=1) as a function of vanpool cost. The plot was constructed at the sample mean distance using King County and a firm size of 2,600 employees and greater (in the sample this corresponds to the most recurring profile of individuals that choose vanpool) as a reference and can be interpreted as the demand for vanpool services with respect to its price. The marginal effect shows how the demand for vanpool is more sensitive to price changes for fares below $3 (daily).

To understand how responsive the demand is to changes in fares, it is useful to employ the concept of demand elasticity. This can be defined as the percentage change in the number of trips demanded, associated with a one-percent change in the cost variable. An estimate of the direct elasticity of mode choice with respect to price was obtained using the cost parameter estimate, by evaluating the price elasticity at each sample observation and then taking a weighted average with respect to the predicted individual probabilities. This addresses the limitation due to the fact that elasticities are linear functions of the observed data, and there is no guarantee that the logit function will pass through that point defined by the sample averages (the sample mean of vanpool cost). Furthermore, the elasticity evaluated at the sample means of the predictors tends to overestimate the probability response to a change in an explanatory variable [16]. The predicted value of the aggregate elasticity for this sample dataset is equal to -0.73, meaning that a 10% increase in vanpool price is associated with a 7.3% decrease in its demand. This result indicates that vanpool choice is relatively inelastic to fare changes. Figure 2 shows the predicted individual elasticities plotted versus the distance travelled by the respondents. The results corroborate what was suggested by the rideshare literature [3, 5, 17]; the belief that individuals are more likely to use vanpool services the longer the distance from home to work. Clearly, it is evident that for trips below 30 miles, the individual elasticities are equivalent to the aggregate estimate. As the distance increases beyond 60 miles, individuals are less responsive to price changes, providing some insight in designing effective fare schedules.

Table 3: Vanpool mode choice – main effect model.

Parameter	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr> Chi-Sq**
Intercept	-6.4270	0.7833	67.3173	<.0001
DIST	0.1248	0.0096	169.9274	<.0001
VP_COST	-0.5714	0.1143	25.0059	<.0001
DA_COST	1.4262	0.0407	1228.7266	<.0001
CP_COST	-5.1168	0.1021	2511.9438	<.0001
VP_SUB	0.9439	0.0838	127.0056	<.0001
CP_SUB	0.2793	0.0794	12.3891	0.0004
TR_SUB	-0.6645	0.0844	62.0520	<.0001
FDUM1	-0.5739	0.9455	0.3684	0.5439
FDUM2	0.3743	0.2277	2.7026	0.1002
FDUM3	0.7437	0.2141	12.0644	0.0005
FDUM4	0.9671	0.2183	19.6242	<.0001
FDUM5	1.1498	0.2100	29.9683	<.0001

Section 132(f) of the US Internal Revenue Code allows most employers to provide a tax-free benefit to employees of up to $100 per month for transit, carpool, and vanpool fares and up to $185 per month for parking fees. The impact of vanpool subsidies (VP_SUB) is represented by a dummy variable indicating the presence of a vanpool subsidy when VP_SUB=1, and its absence when VP_SUB=0; the estimated parameter is 0.94. Marginal effects can also be generated when dealing with a qualitative predictor by analyzing the effect of the dummy variable on the whole distribution by computing the probability of choosing vanpool (using the sample estimates).

Figure 3 shows the two probability functions plotted over VP_COST. The marginal effect is obtained by computing the difference between the two functions' individual values at each fare level. The figure shows that the probability that an individual chooses vanpool decreases as its price increases, and that such effect is far greater for those employees who are not offered a subsidy. The difference is substantial at the sample mean value of VP_COST ($2.26), where the predicted probability of choosing vanpool more than doubles when the employee is offered a subsidy, suggesting a relative strong effect on ridership.

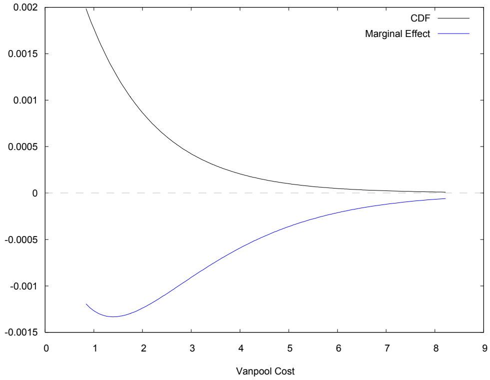

Figure 1: Vanpool demand and price sensitivity.

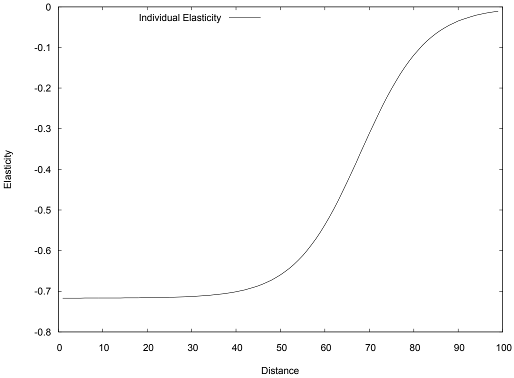

Figure 2: Price elasticity vs. distance travelled.

Based on results showing a significant positive relationship between employer-sponsored ridesharing programs choice and firm size, Ferguson [17] concludes that public policy on ridesharing should focus on larger firms. The results of this model tend to confirm that firm size plays a major role in influencing the choice of vanpool services over SOV. The impact of firm size is statistically significant when the firm size is above the 280 threshold and becomes more substantial for firms with 2,600 employees and above as shown by Figure 4, which plots the probability functions of the statistically significant firm-size dummies over the distance travelled.

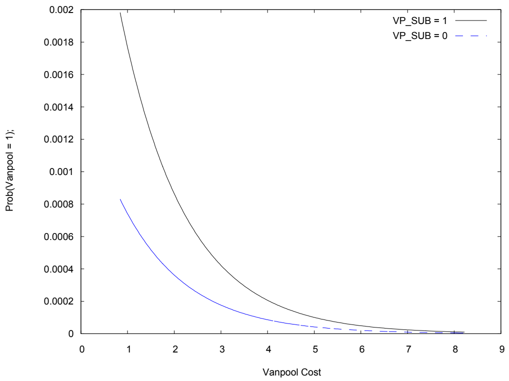

Figure 3: Subsidies and vanpool demand.

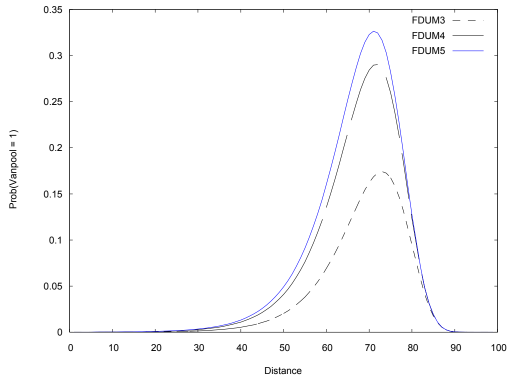

Figure 4: Firm size impact on vanpool demand.

5 Conclusions

It has been demonstrated that employer-sponsored programs, such as vanpool services, could have a dramatic impact on ridesharing alternatives to driving alone [17]. Given that the maximum amount an employee can apply towards the current tax benefit program is $100 per month for transit and vanpooling, it can be argued that employees who collect such a benefit from their employers could be receiving services at a very low cost or even for free and therefore, ridership should be significantly higher. Additional research on price elasticity of vanpool fares and subsidies becomes essential to determine the potential impact of such programs.

This paper investigated the effects of fare pricing and subsidies on vanpool demand. Using employer and employee data from the 1999 CTR program surveys of the state of Washington, a conditional discrete choice model was built to analyze the choice of vanpool services with respect to competing means of transportation as a function of various socioeconomic characteristics.

Results indicate that employer subsidies to vanpool users influence the choice of this mode of transportation with respect to using auto as a means of transportation, providing evidence of a strong positive impact in stimulating ridership. A weighted average price elasticity value was estimated; the value is equal to -0.73, indicating that vanpool demand is relatively inelastic to fare pricing changes. Furthermore, the sensitivity to price fare changes declines as the distance increases beyond 60 miles, as individuals become less responsive to price changes. When considered in the context of subsidies, these results support the evidence that policies other than those intended to affect fare pricing, could play a more important role. The analysis also showed that firm size plays a relevant role in influencing the choice of vanpool services over SOV; to focus on the magnitude of the direct price elasticity, the model controlled for firm size across the sampled individuals.

The analysis presented in this study is increasingly relevant as vanpool employer-based ridesharing program initiatives are based largely on policies that either penalize SOV use or create incentives in the form of fare pricing strategies and subsidies. In conclusion, an enhancement upon the model could be represented by a nested logit model, which allows the existence of different competitive relationships between groups of alternatives in a common nest (thus relaxing the IIA assumption). A next step in the analysis would be to include the examination of the impacts of programs offering vanpool users guaranteed emergency rides home, which provide the assurance and flexibility most typical of SOV.

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