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QUANTIFYING THE EFFECTS OF UPASS: A TRANSIT DEMAND MANAGEMENT STRATEGY

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ABSTRACT

Transportation networks remain fixed, in terms of capacity, for long duration of times due to various reasons such as budgeting constraints, availability of land for more lanes. Whereas automobile growth rate increases each year putting more burden on our road networks. Transportation planners have used different strategies to reduce traffic load on road networks such as encouraging the use of public transportation services, carpooling/ sharing, subsidized bus passes. One such measure is Universal bus Pass (UPass) which has been proven to be an effective solution for transit demand management. While focusing on educational institutes across North America, this research quantitatively analyzes the effects of UPass on transit ridership for the first time. In general, an increase of 50 % has been observed in transit ridership due to UPass implementation and all the cities where UPass was implemented experienced a positive change in transit ridership trends. The developed models are demonstrated through a case study.

Key words: *UPass/ TDM/ Regression Analysis*

INTRODUCTION

Road traffic management and control is a critical problem. High traffic volumes on our road networks not only cause congestion but also result in safety problems (Usman et al. 2010, Usman et al. 2012, Donaher et al. 2012). Universal bus pass (UPass) has been proven to be an effective measure in increasing transit ridership. UPass is an agreement between an organization and transit agencies, where for a fixed monthly fee, unlimited rides are offered to the organization employees. The larger the organization, the more pronounced the effects are. In this regard, educational institutions such as universities have always been ideal candidates for UPass due to large number of students studying there. Universities implement this program because of issues related to parking; students opt in for the low price of rides they get, and transit agencies agree to participate for the assured source of revenue that is involved. Generally, UPass has increased the transit and reduced the auto ridership resulting in cleaner environment, safe and efficient network and making the transit service more attractive. However, currently no tool is available which can gauge these effects systematically. With this in mind, using data from North American universities, this research has attempts to quantify the effects of UPass on transit ridership in post-UPass scenario to better help transportation managers in their planning decisions.

The remaining paper is organized as follows. In Section 2, relevant literature is reviewed and a brief discussion on UPass is presented. Section 3 discusses the proposed methodology. Modeling approaches are presented in Section 4, while results and application are provided in Section 5. Concluding remarks and direction for future work are given in Section 6.

LITERATURE REVIEW

UPass is a scheme where a student ID card is used as a bus pass that allows unlimited rides to its user. Different types of UPass are in practice such as: Compulsory (where all students are required to pay); Opt out (where all students are registered for the UPass program and those who are not interested can opt out); and Opt in (where students who are willing to use the facility are registered for it). Compulsory UPass is the most widely used model and is the focus of discussion in this paper.

UPass offers many benefits to the society as a whole, and to the three partners in the service specifically: the University, the students, and the transit agencies. Benefits to the universities include reduction in the high demand for parking both at present and in future, freeing up valuable land that can be utilized in construction of new buildings or providing green field areas. Students receive the benefit of increased transportation equity, less cost per trip/ride and increased accessibility. Transit agencies view UPass as an assured source of revenue enabling them to better plan their resources and have

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Table 1: List of North American Universities using UPass

U.S. Institutions[1]			
1.	Appalachian State University	18.	University of Tennessee, Knoxville
2.	Santa Barbara City College	19.	Clemson University
3.	University of Nebraska-Lincoln	20.	University of California, San Diego
4.	Auraria Higher Education Center	21.	University of Texas at Austin
5.	Texas Tech	22.	Colorado State University
6.	University of New Hampshire-Durham	23.	University of California, Santa Barbara
7.	Boise State University	24.	University of Utah
8.	University of California, Berkeley	25.	Edmonds Community College
9.	University of North Carolina-Wilmington	26.	Ohio State University
10.	Cal Poly San Luis Obispo	27.	University of Illinois at Urbana-Champaign
11.	University of California, Davis	28.	Virginia Polytechnic
12.	University of Pittsburgh	29.	University Rensselaer Polytechnic University
13.	Cal State Sacramento	30.	University of Massachusetts at Amherst
14.	University of California, Irvine	31.	Western Michigan University
15.	University of South Florida	32.	San Jose State University
16.	Chicago Transit Authority Programs	33.	University of Montana
17.	University of California, Los Angeles		
Canadian Institutions[2]			
1.	University of Calgary	12.	Queen's University
2.	Southern Alberta Institute of Technology	13.	St. Lawrence College
3.	Bow Valley College	14.	University of Western Ontario
4.	Nazarene University	15.	Canadore College
5.	Alberta College of Art and Design	16.	Trent University
6.	University of Guelph	17.	Brock University
7.	Saint Mary's University	18.	Simon Fraser University
8.	McMaster University	19.	University of Victoria
9.	Fanshawe College	20.	Camosun College
10.	Nipissing University	21.	University of British Columbia
11.	University College of the Cariboo		

high fare-box recovery ratios. These will further enable transit agencies to improve their services by increasing the service frequency, fleet size, service hours, and greater coverage. These will attract more ridership from the society as a whole thus forming a positive loop or virtuous cycle. Clean environment is another advantage

[1]. *http://www.vtpi.org/tdm/tdm5.htm*

[2]. *http://www.cutaactu.ca/sites/cutaactu.ca/files/U-PassToolkit.pdf*

of UPass to the society (Transport Canada 2005).

Despite its usefulness and popularity among transit planners, UPass has never been assessed more systematically by the research community. To the best of the authors' knowledge, very limited research exists (Brown et al. 2001, Environment Canada 2005) that has addressed this issue. UPass is one of the many approaches normally taken for transit demand management (TDM) to achieve the goals such as transit oriented development.

The general mode split in Canada is 74% for Auto and 14% for transit (Wu et al. 2004) which is higher for autos than many developed countries across Europe. Being a large country geographically, Canada has an extensive road network to be maintained. This calls for the resources at the disposal of transportation agencies to be used in a smart and proactive manner. Several transportation agencies have entered into agreements with various universities for UPass implementation. Universities have implemented UPass due to infrastructure costs associated with parking, mobility, low traveling cost of attending college, transportation equity, employee benefit, and environmental benefits (Brown et al. 2001, Environment Canada 2005). Historically, UPass has been found to increase transit ridership by up to 50% for the institution concerned, and in some cases it has also resulted in an increased transit ridership of up to 7-8% for the region as a whole. Moreover, it has also resulted in enhancing transit ridership trend positively in the subsequent years (Brown et al. 2001). Brown et al (2001) identified six factors responsible for the subsequent growth: (i) reduced fares, (ii) improved service, (iii) mental maps, (iv) residential relocation, (v) reduced automobile ownership, and (vi) travelling together. However, so far no study has been done which has addressed this issue more systematically and on a broader scale. Available studies have relied mostly on the end results without looking into the contributing factors which play a vital role in the success of UPass. UPass is in place in more than 60 universities in USA and at 22 colleges and universities in 12 in Canada, with many more likely to join. This calls for a more systematic analysis that can be used to assess the effects of UPass proactively. Some of the North American universities participating in UPass are listed in Table 1.

PROPOSED METHODOLOGY

Transit ridership is in general affected by the frequency of the service, area coverage, duration of service availability, service reliability, user cost, accessibility etc. To quantify the effects of UPass on transit ridership, statistical modeling approach is proposed. The proposed methodology consists of:

- Identification of institutes where UPass is implemented
- Collection of data for the year UPass was implemented

Data was collected from various institutes regarding UPass including information about students population, UPass price per academic term, Transit and Auto ridership (in percent) before and after the implementation of UPass denoted by Transit (B), Auto (B), Transit (A), and Auto (A) where A and B are used for After and Before UPass situations (Table 2). All this data comes from the year of UPass implementation, where the effects are more pronounced than the later years. Keeping this in mind the results obtained will be applicable for a one year horizon. Exploratory data analysis was done to ensure the quality and accuracy of the data. Variables were checked for correlation (Table 3), which suggests that no serious correlation exists between the independent variables.

MODEL DEVELOPMENT

Linear Regression model is the most widely employed methodology in a number of fields (Hong et al 2005, Mustakim et al 2006). In case of linear regression, the response variable, generally denoted by , is modeled as a function of covariates in a linear fashion. Mathematically:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k \quad (1)$$

where,

β_0 = intercept,

X_k = th explanatory variable,

β_k = coefficient of explanatory variable X_k,

The coefficients β are estimated using the Least Squares method.

Table 2: Data collected

S. No.	Institution Name	Student Population (000s)	UPass price ($ per term)	Auto (B) %	Transit (B) %	Auto (A) %	Transit (A) %	Change in Transit +%	Change in Auto -%
1	British Columbia	44	50	45	44	24	69	56.82	46.67
2	University of Seattle	7	35	25	21	14	35	66.67	44.00
3	Washington State University	39	47	43	21	30	39	85.71	30.23
4	SFU	22	92	54	37	37	56	51.35	31.48
5	Wisconsin-Milwaukee	24	33	54	12	38	26	116.67	29.63
6	Victoria	14.5	56	57.1	11.1	54.4	17.8	60.36	4.73
7	St. Mary's	0.825	55	35	20		40	100.00	100.00
8	Colorado	31	33	55	2	38	12	500.00	30.91
9	California, Davis Campus	22	53	54	12	38	25	108.33	29.63
10	Boulder, Colorado	24.5	31	56	15	36	34	126.67	35.71
11	California, Los Angeles	63	27	17	17	12	24	41.18	29.41
12	Santa Clara	11	53	76	11	60	27	145.45	21.05
13	Washington Seattle	35	33	25	21	14	35	66.67	44.00
14	California Berkeley	33.5	21	12.5	12.2	11.5	21.7	77.87	8.00
15	Alberta	36	75	24.6	42.9				
16	Carleton University	23			14.34		22.83	59.21	
17	Calgary	26	63					35	
18	McMaster	23	58					25	
19	St. Catharine's (Brook)	11	63					11	
20	Ottawa	30	140					38	
21	Western Ontario	29	52					50	
22	Guelph	17.8	68						
23	Florida	46	53					50	
24	Saskatchewan	8	59		22				
25	Waterloo	26							
26	Wilfrid Laurier	8.7							
27	York				30		60	100.00	
28	Illinois							193	
29	Wisconsin Madison							104	
30	California State Uni, Sacramento							71	
31	Penn. State Uni							160	
32	Uni. Of Pittsburgh							164	

Table 3: Correlation Matrix

	Students (000s)	UPass price/ term	Auto(B)	Transit(B)	Auto(A)	Transit(A)
Students (000)	1					
UPass price/ term	-0.32	1				
Auto(B)	-0.48	0.29	1			
Transit(B)	0.21	0.52	-0.27	1		
Auto(A)	-0.70	0.33	0.94	-0.41	1	
Transit(A)	0.12	0.48	-0.19	0.97	-0.36	1

MODEL CALIBRATION AND APPLICATION

SPSS V.16 was used to fit the simultaneous linear regression models to the data using the functional form given in Equation 1. A backward stepwise elimination process was performed until all the non-significant variables were removed from the model.

Two Models were developed for both Auto and Transit in the post UPass scenario with results given in Model – 1 and Model – 2. Both the models are insensitive to the UPass price which is quite obvious as the scheme is compulsory.

Model 1

$$Transit\left(A\right) = 3.212 + 1.249\,Transit\left(B\right) + 0.495\,Auto\left(B\right) - 0.490\,Auto\left(A\right) \quad R^2 = 0.985$$

Model 1 has a high R^2 value and makes sense intuitively. High value of $Auto\left(B\right)$ means there is a high chance of people to divert from auto to transit. A high value of $Transit\left(B\right)$ will mean a strong transit culture, thus having even greater ridership after UPass. Similarly, increase in $Auto\left(A\right)$ with negative coefficient means that transit ridership will decrease at the cost of auto ridership

Model 2

$$Auto\left(A\right) = 2.832 + 0.795\,Auto\left(B\right) - 0.204\,Transit\left(A\right) \quad R^2 = 0.934$$

Model 2 has a high R^2 value and makes sense intuitively. High value of $Auto\left(B\right)$ will increase $Auto\left(A\right)$ showing that the institution has a high auto culture with most people using auto mode. Similarly, increase in $Transit\left(A\right)$ with negative coefficient means that transit ridership will increase at the cost of auto ridership.

To find the mode split after UPass, both Model 1 and 2 need to be solved simultaneously for $Transit\left(A\right)$ and $Auto\left(A\right)$ for the given values of $Transit\left(B\right)$ and $Auto\left(B\right)$.

In order to further assess the validity of the developed models, predicted values from the model were plotted against the actual values (Figure 1).

Figures 1 and 2 depict that both the models fit the data very well.

APPLICATION OF THE DEVELOPED MODELS

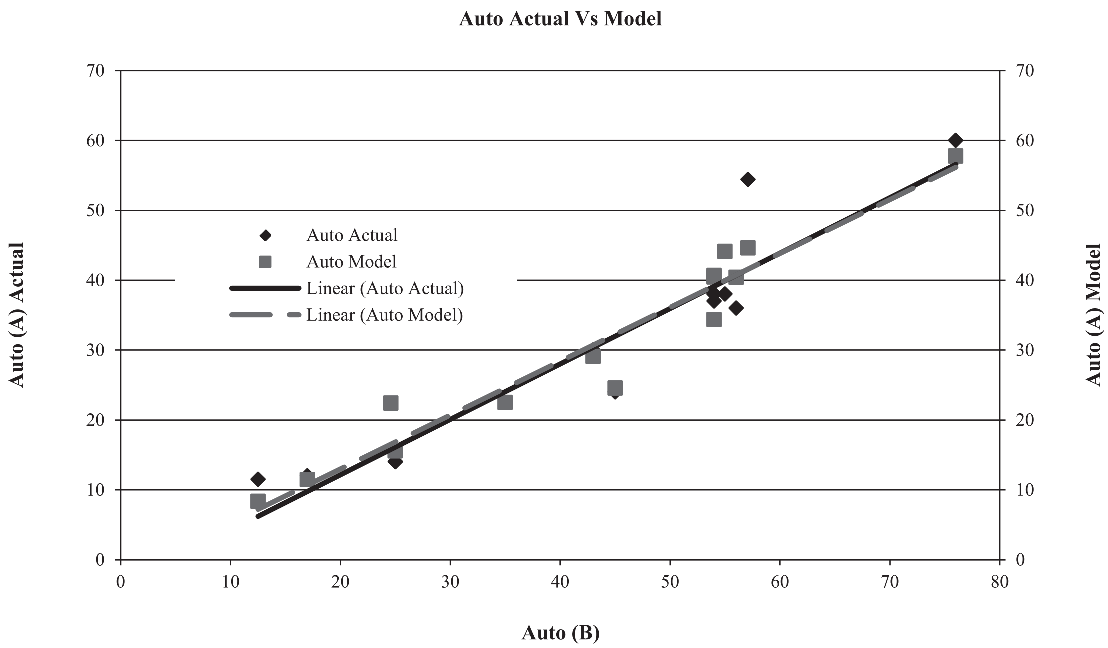

Figure 1: Predicted vs observed auto values

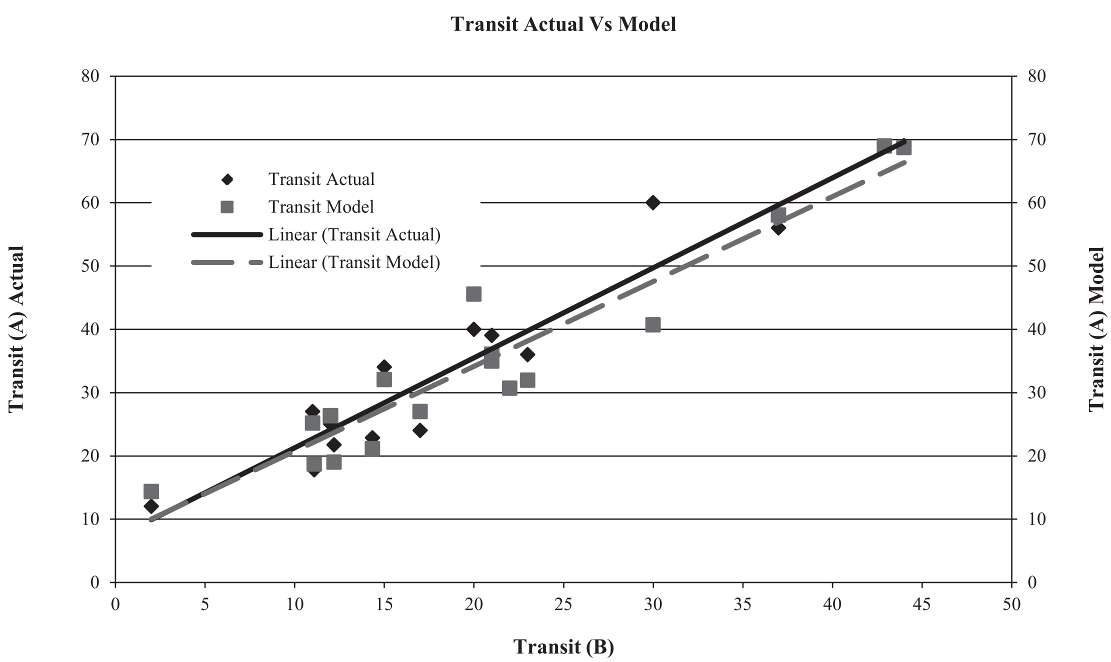

Figure 2: Predicted vs observed transit values

To show the benefits of UPass, the developed models are applied to the University of Waterloo (UW), Canada, the ninth largest Canadian university, with a total enrollment of 26,086.

Benefits to the University:

Currently UW has 5500 parking spaces available in twenty parking lots . This gives an average value of 275 spaces per parking lot. Average parking permits sold are 3000/term. There are also 235 free parking spaces available (for three hours) near waterloo park. The average maintenance cost is $ 15/ sq-ft/year and the cost of new construction $ 2500 per space (University of Saskatchewan 2003, Wu et al. 2004). Considering an 18’ x 10’ parking space the maintenance cost is $ 2700/space/year

To apply the models, values of the transit and auto ridership were obtained. The current mode split at University of Waterloo (UW) is Auto 12 % and Transit 7 %. The value of 7 % for Transit came from Regional Municipality of Waterloo (RMOW) survey (RMOW, 2005) conducted for Rapid transit. The Transit percentage is calculated as follows:

Student Population at UW = 26,000

Parking spaces in parking lots = 5,500

Average Spaces Occupied (Paid) = 3,000

Percentage of utilization = 3000/5500 = 55 %

Free parking spaces = 235

Free Spaces Occupied = 130 (assuming 55% utilization)

Total Parking Spaces utilized= 3000+130= 3130

Percent using Auto, $Auto(B)$=(3130/26000) x 100 = 12%

Putting these values in Model 1 and 2 and solving simultaneously we get:

$Auto(A)$ = 9.69 % (A reduction of 19% from the previous value)

$Transit(A)$ = 13.15 % (An increase of 88% from the previous value)

Using the new values obtained, financial benefits to the UW are calculated as detailed in the section below:

Decrease in Auto trips = $Auto(B)$ – = $Auto(A)$ 12 – 9.69 = 2.31 %.

Converting these trips to parking spaces = (2.31 x 26000)/100 = 600 spaces or trips.

This means 600 spaces x 2500 $/Space = $ 1,500,000 savings in terms of new construction or 600 spaces x 2700 $/space = $ 1,620,000 saving from maintenance perspective per year.

Pre-UPass vacant spaces = 5500 – 3000 = 2500

Post-UPass vacant spaces = 2500 + 600 = 3100

Using the average spaces per parking lot and converting these to parking lots:

Pre-UPass = 2500/275 = 9.1 say 9 vacant parking lots

Due to UPass = 600/275 = 2.2 say 2 vacant parking lots

Total = 9 + 2 = 11 vacant parking lots.

CONCLUSIONS AND FUTURE WORK

Due to high volumes of traffic at our road networks, transportation managers are using various methods to take private vehicles off the road and encourage the use of transit. UPass is one such method, which has resulted in an increase in transit ridership up to 50% at the participating institutions. UPass is also considered an important TDM measure by the regions/municipalities in achieving their targets of increased ridership. It is helpful from environmental perspective. Many benefits such as safety, mobility, frequent service and increased service hours can be associated with UPass. It decreases the parking demand in universities, offers an assured source of revenue to transit agency, and provides a cheap and efficient means of travel to the students. This research has for the first time attempted to develop quantitative models for post-UPass scenarios. Data from several universities across North America was obtained to develop the proposed models. The proposed models are capable to predict the post-UPass mode split, thereby enabling transportation officials to make informed decisions regarding transportation planning.

Application of the models shows that UPass will result in a reduction of 19% in Auto rider ship and increase transit ridership by 88%. Upass will also result in availability of an additional 22% parking space resulting in a savings of 1.5 to 1.6 Million dollars. In brief, UPass is a scheme with many advantages and apparently no disadvantage.

Due to lack of available information, the authors' did not analyze the optional UPass services. Our future work will take the optional scheme as well as the financial information (Student fee) of the users – an important predictor of mode split, into consideration.

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