The 31% solution:

University transit pass program at the Université de Sherbrooke.

Supervised Research Project Report

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ABSTRACT

Deep Discount Group Pass (DDGP) programs are innovative fare reduction techniques that encourage people to leave their cars at home and take public transit instead. This modal transfer can offset many issues encountered by an institution, its members and the transit authority while generating benefits for all.

The current research examines the real advantages for partners involved in the context of a university transit pass (U-Pass) implemented at the Université de Sherbrooke (UdeS). After having implemented the U-Pass, students from the university who traveled by car either switched to transit (switchers) or continued to use their car (non-switchers). For our analysis we used data from the university-wide survey on student travel behavior, which we ran through the Random Forests (RF) classification method to identify both dominant profile and opinion variables responsible for switching and not switching to transit. Our analysis shows that the 31% increase in public transit modal share was generated by students who typically study in theology, ethics and philosophy, physical education or human sciences; live relatively close to UdeS; do not have access to a car; chose their place of residence based on proximity to transit or their study area; were car passengers prior to the U-Pass; are in their first and second year of undergraduate studies; are 28 years of age and younger, and are part-time workers.

By identifying the dominant characteristics of switchers, the study allows other academic institutions to estimate the success rate of a future U-Pass by calculating the number of potential switchers.

Also, information on non-switchers can guide officials to better target a publicity campaign aimed at reducing the number of car users and further relieve parking issues. In addition, using student's opinion regarding the quality and level of transportation services, we present transit operators and UdeS officials with insight to adjust their service to better answer the needs of students.

Keywords: Transportation Demand Management (TDM), public transit, universities, discount passes

RÉSUMÉ

Les passes universitaires (U-Passe) sont des techniques innovatrices de réduction de la tarification du transport en commun (TC). Elles offrent aux membres des établissements qui l'adoptent un incitatif à revoir leurs habitudes de déplacement et visent le transfert des automobilistes vers le TC. Ce transfert modal a le mérite d'éliminer certains problèmes en matière de transport pour les établissements, ses membres, ainsi que pour la société de transport tout en générant des bénéfices pour tous.

Cette recherche fait la lumière sur les avantages dont bénéficient les partenaires impliqués dans la U-Passe implantée à l'Université de Sherbrooke (UdeS). Après sa mise en place, les étudiants de l'université qui effectuaient leur déplacement en automobile ont soit transféré au TC ou ont continué de venir en voiture. Notre analyse utilise les données d'un sondage qui questionnait tous les étudiants sur leurs habitudes de transport. Nous avons ensuite appliqué la méthode de classification Random Forests (RF) pour identifier les variables responsables du mutation des étudiants ou non vers le TC. Notre analyse montre que ceux qui ont participé à l'augmentation de 31 % de la part modale du TC ont les caractéristiques suivantes : étudient en théologie, éthique et philosophie, en éducation physique ou en sciences humaines; habitent relativement proche de l'UdeS; n'ont pas accès à une automobile; choisissent leur lieu de résidence en fonction de la proximité au TC ou de leur lieu d'étude; étaient des passagers avant l'arrivée de la U-Passe; sont à la première ou deuxième année de leur baccalauréat; ont 28 ans et moins et travaillent à temps partiel.

En identifiant les traits dominants de ceux qui répondent favorablement à la U-Passe, cette étude permet à d'autres institutions académiques d'estimer le taux de succès d'une future U-Passe en se basant sur le profil de leurs étudiants.

Aussi, les caractéristiques de ceux n'ayant pas transféré peuvent aider l'UdeS à mieux cibler une campagne publicitaire destinée à réduire le nombre d'utilisateurs de l'automobile pour apaiser les problèmes liés au stationnement. De plus, en utilisant les données sur l'opinion des étudiants quant aux services de transport offerts, nous sommes en mesure de proposer des ajustements de l'offre pour mieux répondre aux besoins des étudiants de l'UdeS.

Mots-clés : gestion de la demande, transport en commun, université, passe à tarif réduit

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1. INTRODUCTION

In Canada, the federal government is pressuring universities to implement sustainability programs and reduce their carbon footprints. More than ever, universities must adapt their activities and implement new practices around the principle of sustainability. In our relatively affluent society, the car remains a status symbol despite its negative impacts on the environment. This raises the challenge to make public transport more attractive. For universities, finding innovative Transportation Demand Management (TDM) strategies for students and staff should be at the forefront of its preoccupations.

DDGP programs are innovative fare reduction techniques that encourage people to leave their cars at home and take public transit instead. This modal transfer can offset common issues encountered by an institution, its members and the transit authority while generating benefits for all.

This work examines the real advantages for partners involved in the context of a DDGP implemented at UdeS. We then suggest general improvements that can make these programs more attractive to a wider range of institutions. In addition, we draw from the complete profile of students who continued to use their cars in order for UdeS and other universities to better target their promotion campaign in order to exceed the 31 percent solution.

For transit agencies, DDGP measures are particularly attractive due to insufficient funding sources to cover both running and maintenance costs, which prevents them from

focusing on other development opportunities. Frequently, agencies resort to fare increases in order to generate additional revenue or cut back on service to reduce operational costs. Both of these measures result in reductions in ridership, consequently hurting their total revenue. “In order to avoid this downward spiral, turning to ridership increases as a starting point seems to be part of the solution agencies are seeking” (Hester, 2003, p. 7).

DDGP does not call for mere fare reductions but rather a shift in the way transit agencies collect their fare revenues. This measure adopts a similar scheme as group purchasing (made famous by firms such as Groupon). The concept is based on offering a significant rebate on a bulk purchase made by multiple customers. In the case of a U-Pass, the purchased good is a pass that grants unlimited access to transit service while the buyers are generally students – or in some cases – all members of the university community. Universities are particularly well suited to buy into these programs since all its members share a common and high-density destination. Also, students are generally very supportive of such a program, as they allocate a much larger portion of their annual income to transportation, making them particularly sensitive to price changes.

For universities, a partnership with the transit agency allows it to expand the mandate of its sustainable transportation plan beyond the campus gates. Indeed, universities need to shift from parking planners – focusing on its member’s point of arrival – to active participants in the travel decision process of its members at their point of departure (Kirkpatrick, 1998).

For the transit agency, the U-Pass offers a dedicated, indexed and recurrent source of income. Precisely what is required to start an upward spiral. These programs have proven

to be successful with significant direct and indirect benefits for all parties involved (students, university, transit authority), creating a win-win-win situation.

Although the U-Pass at UdeS has effectively resolved transportation issues on campus and has been running successfully for 7 years, this measure has yet to be reproduced elsewhere in Quebec. Most universities are still unaware of the gains available through such a program.

In summary, we seek answers to the following questions: What are the basic characteristics of a U-Pass program? What reasons make students switch to public transportation? This report begins with a literature review on the reasons for introducing a U-Pass program – including how it works and who benefits from it – through a comparison of previous case studies. We then shift our attention to UdeS's program and its generated results. The following section presents the data and methodology used to conduct a Random Forests (RF) analysis. Finally, the conclusion presents a number of recommendations for U-Pass programs in general and improvements to Université de Sherbrooke's U-Pass program.

2. LITERATURE REVIEW

2.1. Terminology

First, various generic terminologies are used to describe programs that offer discounted transit fares for a group of users. These terms refer to a particular aspect offered by the

programs: Deep Discount Group Pass (DDGP) (Nuworsoo, 2005), Group Transit Purchase Program (GTPP) (Block-Schachter and Attanucci, 2008) University Pass or U-Pass, (Meyer and Beimborn, 1998; Hester, 2004), Unlimited Access (Brown et al., 2001, 2003; Isler and Hoel, 2004), Fare-free transit (Brown et al., 2003; Boyd, et al., 2003), Eco-Pass (Shoup, working paper). In this study, university-based programs will generically be referred to as U-Pass, neighborhood and employer-based programs will be referred to as Eco-Pass, and jointly they will be referred to as DDGP. Although the bulk of this study examines university-based programs, the model holds potential to be further developed in other contexts such as institutions, companies and neighborhoods.

2.2. Why implement a U-Pass?

Universities are large institutions that generate important traffic flows. Continuous increases in student enrolment exacerbate issues on campuses. Universities are struggling between keeping up with the rising demand for parking and the need to adopt more sustainable approaches. Meanwhile, transit agencies are trying to find new ways of covering their operating expenses without resolving to harmful measures such as fare increases or service reductions (Meyer and Beimborn, 1998).

University pass programs hold the potential to create a winning situation for all participants, whether student, the university or the transit authority. While a further section will thoroughly describe all benefits for the parties involved, it is important to highlight the context of their implementation and their distinction over existing price strategies.

A U-Pass is considered an effective Transport Demand Management (TDM) solution that contains two sets of benefits. First, it ameliorates student accessibility to transit by cutting down the cost of traveling by bus, which results in ridership increases. For the transit agency the U-Pass represents secured revenues and a step forward to provide new and improved service to the benefit of students and other users. The second set of benefits involves parking rate increases at the university and acts as a disincentive measure. By discouraging students to travel to university by car, parking and accessibility issues are partly relieved.

As pointed out by Hester (2004) a shift in fare policy trends has widened the number of differential fare options to the detriment of the flat base fare. Differential fare options range from zone identifications and peak/off-peak periods to bulk purchases and pre-paid options for limited periods of time, such as a day, a week, a month, etc. In most cases, these differential fares impose usage restrictions to the use of public transportation. This is the transit agency's way of applying a common marketing strategy that consists of segmenting the market of demand through several buying options. These fare options hold the potential to increase transit ridership. They are attractive to users as they offer a discount over single-ride fare and eliminate the burden of having the exact change to pay for every entry (Nuworsoo, 2005; Meyer, 1998). In turn, the adoption of these new fare structures reduces operational costs for the agency as it reduces the number of individual transactions (Brown et al., 2001).

DDGP programs are innovative fare policies the university can build on to increase positive outcomes. The following section describes the nuts and bolts of how DDGP programs work with a focus on university-based programs.

2.3. How U-Pass and DDGP programs work?

The main purpose of DDGP programs is to provide a new way of paying for transit (Brown et al., 2003). The pricing schemes used in U-Pass programs will be addressed more thoroughly in section 2.5. The common element required to implement a DDGP program is to have all members be part of a common group and, in some cases, share a common origin or destination. Therefore, three types of location-based programs have been developed: campus-based, employer-based and neighborhood-based programs (Nuworsoo, 2005). In these cases, the university, the employer or the neighborhood association pays the yearly cost of the service to the transit authority in a single transaction. Then, participants of the program typically contribute for a part of the costs through university fees, payroll deductions or inscription fees.

With regards to the main elements of DDGP programs, three are consistently present:

(1) Coverage for all members of an identified group;

(2) Unlimited access to transit for all group members during a predetermined period; and

(3) Drastically discounted fares compared to regular pass prices.

Also, some employer-based programs offer an emergency ride home (Nuworsoo, 2005).

Universities offer the perfect setting in which to implement a DDGP program. They represent a large number of people traveling to the same destination, and students tend to be more responsive to cheap transportation options and initiatives that benefit the environment. For this reason, discounted transit passes have been more widely developed in university contexts than in any other large institutions or employers (Hester, 2004). By 2002, more than 60 U-Pass programs existed in the United States (Shoup, working paper), while 20 had made their appearance by 2004 in Canada (U-Pass Toolkit, 2004).

Three types of university coverage options exist: opt-in, opt-out and mandatory participation (Hester, 2004). The opt-in coverage allows students to enroll in the program on a voluntary basis. This method is subject to attract only *captive riders*[1], which are riders that are already used to taking transit. Leaving out *choice riders* (or occasional riders) and *potential riders*, generally car drivers or active transport users, minimizes the possibility of increasing ridership. In turn, it holds the risk of becoming a vicious circle where a low level of participation leads to a higher, unattractive price. The opt-out coverage automatically enrolls all students, but with the option of opting-out if desired. This method is subject to keep both *captive* and *choice riders* while *potential riders* will have a tendency of opting-out, resulting in higher cost per participant. Finally, mandatory participation automatically enrolls all students, but without the option of opting-out. This method makes individual cost per participant the lowest of all as the total expenditure can be divided between a larger number of participants. With a lower fare price, transit services can hope to also

[1] Kevin J. Krizek and Ahmed El-Geneidy divide public transit riders into eight categories: *"the market for existing transit services can be divided into eight different types of commuters with varying preferences. The crudest divide is between regular and irregular commuters(…). Users of the system can be divided into captive and choice riders, while non-users can be divided into auto captives and potential riders."*

attract *auto captives* and raise the agency's likelihood of increasing total ridership. Together, these advantages create a virtuous circle where a higher participation rate leads to a lower, attractive price. Also, more ridership justifies service improvements that will benefit all transit users. Translink, the transit authority for the city of Vancouver, has made mandatory programs a prerequisite for providing service to any institution with a DDGP program [2].

In a paper by Brown et al. (2001), three universities offering three different coverage options were surveyed (Table 1).

Table 1 U-Pass participation rate and cost per participant based on coverage option

	Partial coverage		*Universal coverage*
	Opt in	Opt out	Cannot opt out
	University of California, Irvine	University of Washington, Seattle	University of Colorado, Boulder
Percent who participate	1% of students	74% of students, faculty, staff	100% of students
University's cost per participant	$246 per year	$130 per year	$41 per year

Adapted from Brown et al., 2001

Partial-coverage programs show a higher cost per participant because they have fewer students who participate. The University of California (Irvine), with opt-in coverage, had 1 percent of its students participate with an individual cost of 246$ per year. The University of Washington (Seattle), with opt-out coverage, had 74 percent of its students,

[2] http://www.translink.ca/en/Fares-and-Passes/Student-Passes/U-Pass/U-Pass-FAQ.aspx#opt-in, last accessed April 6, 2011.

faculty and staff still enrolled in the program, which led to an individual cost of 130$ per year. On the other hand, the University of Colorado (Boulder), which covered 100 percent of its students, managed to bring the individual cost down to 41$ per academic year. As we will see later on, the actual discount offered to students depends on the university's willingness to participate in paying the cost of the U-Pass. Thus, when compared to the next best-priced transit pass, student savings are not linked to the coverage scheme adopted by the university.

2.4. A business model

2.4.1. Pricing scheme established by the transit agency

Discounted transit fares are a common marketing strategy. Transit authorities apply these to increase the sale value of each of their transactions. The model is based on bulk-purchases of transit tickets or passes. The reduced-fare is proportional to the amount of tickets purchased in one transaction or the amount of time during which the pass is valid. For instance, at the Société de Transport de Montréal (STM), Montreal's transit authority, the weekly pass offers a minimum of 27 percent discount when compared to 5 round-trips using regular tickets that are priced at 3$ (5(week-days) x 2(for round-trip) x 3$). When buying for a longer period of time, the monthly pass offers a 39 percent discount compared to 40 regular priced tickets (1,80$/ticket instead of 3$)[3]. Conventional transit passes are priced to reflect frequent riders' needs, to provide a more affordable option to the regular fare, and to recognize their liability as customers.

[3] http://www.stm.info/tarification/tarifmontreal.htm, Last accessed on April 3, 2011.

Because they target frequent users, these passes suffer from adverse selection (Brown et al., 2001). Adverse selection is the term used in the context of insurance coverage. It refers to the increase of insurance premiums for every person insured due to the tendency of people with higher probability of loss to purchase more insurance. In the case of transit passes, adverse selection occurs because frequent transit users are more likely to buy passes. Based on this hypothesis, transit agencies must adjust the price of their passes upward, which makes them unattractive for occasional users.

2.4.2. What elements contribute to lower the cost of U-Pass programs?

The literature has identified several key factors that help transit agencies lower the cost of U-Pass programs (Brown et al., 2001, 2003; Hester, 2004): (a) bulk purchases, (b) maximizing transit capacity, (c) avoiding adverse selection.

a. Bulk purchases

Similar to conventional passes, U-Pass programs also obtain their discount through bulk-purchases but with two main differences. First, the pass covers longer periods of time, typically paid for the whole semester or the whole year in advance. Second, payment of the pass is no longer made through individual transactions, but in one transaction between the university and the agency. This significantly reduces transaction costs, such as labor and printing expenses, compared to selling individual passes.

b. Maximizing transit capacity

Maximizing transit capacity is another way of reducing the costs of the program. A U-Pass can generate more revenues for the transit agency if no additional buses are required to accommodate new users, as they will fill unused capacity on buses. The literature identifies several cases where program members filled empty seats on routes that had excess capacity (City of Berkeley's Eco Pass program, Nuworsoo, 2005; UC San Diego, Brown et al., 2001; UWM Milwaukee, Meyer and Beimborn, 1998; CU Boulder, Hester, 2004).

U-Pass programs have an added advantage: it is known that students are more likely than others to use transit during under-used off-peak hours because of their irregular schedules (Brown et al., 2001). To illustrate this point, Brown et al. stated the case of the Chicago Transit Authority where it was found that "69 percent of all student transit rides were made during off-peak hours while only 52 percent of all transit rides were made during off-peak hours" (Brown et al., 2001: 16). Therefore, through a U-Pass program the transit agency reduces the cost per kilometer of a bus by simply filling empty seats on routes that have already been paid for.

c. Avoidance of adverse selection

Adverse selection is only present in partial-coverage programs. Students who decide to opt-in or not opt-out of the program are regular transit riders. Since they were the most lucrative group of users for the transit agency prior to the program, the university has to match the agency's revenue expected from those students. Consequently, they increase the program's cost per person. In the case of a U-Pass implemented through mandatory

participation, it is possible to avoid adverse selection and therefore lower the cost per person. If every student owns a transit pass, the costs will be split between frequent and infrequent transit riders.

All of these elements create variances in the transit authority's cost either because of administrative expenses or, most importantly, the requirement for additional bus service. In theory, the higher the benefits from each of these factors are, the lower the U-Pass can be priced.

2.5. How are U-Pass programs priced?

The cost paid by the university is determined according to two elements: (a) The probability of use and (b) The amount of service on the routes that will be served. These two conditions are present for all DDGP programs.

This point can easily be understood through the following table. It shows the Santa Clara Valley Transportation Authority's (VTA) EcoPass annual pricing based on location and number of employees.

Table 2 Costs of an EcoPass based on the size of the company and its location

	Number of employees			
Location	1 to 99	100 to 2,999	3,000 to 14,999	15,000 +
Downtown San Jose	$144	$108	$72	$36
Areas served by bus & light rail	$108	$72	$36	$18
Areas served by bus only	$72	$36	$18	$9

http://www.vta.org/ecopass/ecopass_corp/eppricing_static.html, last accessed on April 4, 2011

Table 2 shows that VTA's EcoPass is priced higher in central downtown since a lot of service is required to answer the large demand from transit users. Additionally, a low number of employees make the price higher as the cost of the pass is being divided between fewer people. The same goes for U-Passes that are priced on probability of use and the level of transit provided to get to the university campus.

Universities generally proceed in two ways to estimate the probability of use from students. Transit agencies that have electronic card readers can benefit from precise boarding data. Using smart card technology, Automatic Passenger Counters (APC) onboard buses compile information about student usage of the transit system. This technique is the most precise way of determining the cost per ride.

Transit agencies that have not implemented a smart card system usually base their price on university enrolment numbers, which they combine to manually counted student boardings. This technique is less precise since no descending data is compiled, and it usually only leads to determining the approximate cost per rider.

In any transit pass program, the revenues expected by the agency must be equal or higher than the revenues perceived prior to the program. Therefore, costs generated by the addition of buses or by the addition of new routes must be covered by the university (Nuworsoo, 2005). If the level of service has not changed, charges should remain the same since the community has already paid for the service.

2.5.1. Lowering the costs

Brown's study (2001) unveiled that 23 out of the 35 investigated universities use student fees as their primary source to fund their U-Pass program. Another study by Daggett and Gutkowski (2003) with 23 universities revealed that only 39 percent of programs have seen their fees lowered by the contribution of the university, while 52 percent of faculty and staff programs have a university contribution. Researchers expressed their surprise, saying that "Faculty and staff are considerably more able to pay a transit fare, i.e., the percentage of their annual income used for transportation is significantly lower than that of students" (Daggett and Gutkowski, 2003, p. 28). Officials at the University of Monash (Australia) also insist on student financial preoccupations and add that « students are at a stage in life when they perceive themselves as largely indestructible but poor », they concluded after holding focus groups with students (Cooper and Meiklejohn 2003, p. 6).

Since most universities adopt a U-Pass to improve parking on campus (Brown, 2001), making students pay the entire bill to resolve university transportation issues is inappropriate. Brown argues that since the university and its students benefit from the U-Pass they should both contribute to its financing. Once the transit authority has established the cost at which it is willing to provide students with the U-Pass, the university holds the power to apply different funding schemes to further lower the price for its students. In cases where universities contribute to finance U-Pass programs, they do so by increasing their parking rates. This practice should not only be encouraged for its ability to lower the price for participating students, but more so because it plays a crucial role in the success of the U-Pass program as a disincentive for automobile drivers (Meyer, 1998).

Having the university participate in financing part of the program lowers the cost for students, thus further increasing the likelihood of the program to be adopted at student referendums. Finally, as mentioned earlier, having the university subsidize the program through its parking revenue holds the added benefit of discouraging car use and can thus help increase the success rate of the U-Pass.

2.6. Perceived cost and quality requirements

2.6.1. Perceived cost

Once a U-Pass program is implemented, students no longer deal with a weekly or monthly out-of-pocket fee. In exchange for the service provided, universities become responsible to pay an annual sum to the transit authority on behalf of all students. Meanwhile, when students contribute financially to the cost of the U-Pass, the amounts are included in their tuition fees. For students, the cost of taking transit is no longer explicit in cash and is therefore said to be "sunken" or "hidden" (Shoup, 1999; Hester, 2004) as it is less apparent. When compared to each student's tuition, it is safe to assume that the U-Pass contribution only represents a marginal sum. It appears amongst numerous fees imposed by the institution, and is therefore largely hidden. This situation provides an opportunity to question the amounts discounted in such programs. It is believed that a significant discount will result in more students joining the program. The counter-argument to this reasoning is that students' perception of the value of the transit service will decline and less students will be attracted to transit.

We argue that three elements are most effective in attracting new users and that the actual amount of the discount comes only second in the case of mandatory programs.

First, people are attracted by the fact that a discount is offered to them; they have little interest for the exact amount as long as they save money. Second, because the amount paid by students is unapparent, they are not reminded of the cost of taking transit. This new way of paying for transit eliminates the cost per ride factor as an influencing element for not taking transit. Our third point enriches the previous one in that the perception of benefiting from a free service is amplified by the fact that students can now board buses without paying a direct fee. Moreover, they benefit from unlimited access to transit, eliminating inconveniences from time-limited transfers.

Regarding student contribution, a low fee may trivialize the transit service provided by making it seem like a low-cost good with a low value. A higher student contribution, on the other hand, may act as a greater incentive to use the service, as people (particularly students) will feel the need to maximize their return on investment. Also, this would increase the switching rate to public transit, as students will want to avoid paying for two transportation options (the U-Pass and the mode they used prior to the U-Pass).

2.6.2. Quality requirements

Having established that a U-Pass results in significant savings, let us consider how these savings can be distributed. So far, the traditional way has been to offer a discount to students. As we argued above, this discount may prove to be insignificant in the overall education fees on an individual basis. An alternative way, we are prepared to argue, would

be to offer a smaller discount and invest the additional revenues to improve the quality of the service. This would act as both an incentive for students to switch to public transport as the quality of the transit service would improve, and as a disincentive for drivers as a larger mandatory fee will increase costs of driving to school. Further, the general public would benefit from an improved bus system. In turn, the higher quality of service will attract new passengers that will generate additional income since they would be paying the regular fare.

Thus, we argue that the discount is less significant than it first appears and could be substituted by an improved service to U-Pass members, and the community.

Students not using transit

The cost of using a car to commute to campus must now include the contribution to transit. Since they are paying twice for a transportation service, the burden of using a car increases and may act as an incentive to leave the car at home.

The following section highlights and explains the most important benefits incurred for all parties involved.

2.7. Benefits of U-Pass programs

2.7.1. For universities

An obvious benefit for universities comes from savings related to all infrastructures and facilities related to intensive use of cars by students and staff (if the latter are allowed to participate). The most obvious saving involves space dedicated to parking, which becomes exceedingly expensive as more campuses require their land for office space and research facilities to accommodate larger student body, and as off-city campuses are increasingly embedded in sprawling suburbs. The decrease of demand for parking induces benefits that range from major financial relief due to a decrease in road and parking maintenance to avoiding building additional costly infrastructure. Since every student who switches from driving to taking transit to get to university results in one less car on campus, it becomes possible to reconvert parking spaces into academic facilities that could generate revenues instead of cost or even green space. Also, removing cars from campus helps create the safe and attractive atmosphere that universities want to promote in order to draw prospective students.

Although exact numbers may vary according to the size of the university and nearby settlements, if a larger relative number of students may prefer to live off-campus in part because of lesser costs, improving student mobility throughout the city by public transport can have a serious impact on required university residential facilities. If so, a lesser proportion of students may choose to stay on campus and thus relieve pressure on students' housing infrastructure.

In all, more public transport will translate in more land dedicated to educational and leisure purposes including green areas.

In recent years, a strong preference has emerged in developing environmentally friendly facilities. Universities are at the forefront of this societal demand and are trying very hard to expand the norms of durability and self-reliance to set examples for the community and attract attention by being exemplary corporate citizens. Thus, developing incentives that will refrain from individual car use and actively promote less environmentally damaging solutions, such as public transit or active transportation, will necessarily be part of any university's pledge to reduce its overall production of direct and induced GHG emissions. Turning the whole campus into a showcase of an environmentally friendly settlement will enhance its reputation, will be considered a manifestation of intellectual dynamism of creativity and innovation, and will garner praise as an overall expression of respect for the community. Such a program, at least in their objectives, can only receive approbation of its students and capture the attention of future students, thus helping to retain and recruit students (Toor and Havlick, 2004).

2.7.2. For students

Multiple benefits exist for students although they greatly differ depending on whether they switch to transit, stay in their car or continue to use active modes of transport.

Students who switch

U-Pass comes as a significant complement to transportation options available to students.

Mostly, it increases the cost of using a private vehicle to get to school. Among the benefits, the most tangible would be the important cut in travel costs between 40 percent to 94 percent reduction on regular fare price (Nuworsoo, 2005). Programs are usually designed in such a way that they allow for flexibility. For example, you may use public transit to run any errand within the territory covered by the transportation system on any moment of the day, on any day of the week. As a result, being part of the student community subsidizes your non-student activities.

Low-cost transit does more than just allow students to pay less money to cover a set distance. U-Pass allows students to increase housing and shopping options giving them access to less expensive goods. To the extent that the increase in mobility is taking place through the use of transit, students cover more distance while fewer cars circulate on city streets. A U-Pass also has a positive impact on transportation equity, as it allows less fortunate individuals to spend less money on their transportation needs, thus liberating resources for other uses (Toor and Havlick, 2004).

Finally, a U-Pass offers the convenience to its participants of not needing to worry about having exact change for the fare box (Nuworsoo, 2005; Meyer, 1998). Campus-based programs usually combine student ID cards and transit passes into one, either by upgrading to a smart card system or through the addition of a sticker.

Students who do not switch

Non-switching students are put at a disadvantage in a number of ways. First, since most programs do not allow for opting out, drivers end up paying twice for transport services. As mentioned, most universities who have adopted a U-Pass subsidize its cost through parking revenues but often also increase these charges as a result of the additional expenses incurred. This measure gives an added incentive to leave the car at home, but students who rely on a car will see their operating costs substantially increase. The counter argument would be that since the adoption of a transit pass program substitutes the construction of additional parking, which is an expensive undertaking, parking charges would have increased anyways.

Students who continue to use the car still incur several indirect benefits: less traffic congestion, more parking availability (Brown et al., 1999) and cleaner air (Meyer and Beimborn, 1998). However, it is important to note that remaining car users represent potential switchers who have not found the benefits to taking transit to be sufficient for them to leave their cars at home. The case study on the Université de Sherbrooke will explore more in depth the characteristics of these students and subsequently offer solutions to improve the U-Pass at UdeS.

Given all indirect benefits enumerated above, active mode users are the least advantaged by a U-Pass program. This can be offset if transit authorities provide bicycle racks on their buses to increase multimodal opportunities. Nonetheless, benefits exist. Through focus group discussions led by Meyer and Beimborn (1998), students said that

having easy access to transit holds the added benefit of acting as an insurance policy by providing them with a valid transportation mode as a backup.

2.7.3. For the transit authority

Across all types of programs, whether university, employer or neighborhood-based, a recurrent benefit to the transit agency is the guaranteed revenue. This allows the transit agency to diminish its reliance on fare box revenue (Meyer and Beimborn, 1998) and facilitates the agency's financial planning (Hester, 2004). For large programs like a university-based U-Pass, the revenue stream is likely to be adaptive to service increases, therefore it does not only guarantee to replace the lost revenues from the fare box but also covers the costs of added service. In turn, this added service can attract other users and may increase revenues, as will be discussed further. A simplified transaction operation is another benefit as the representative of the group, in our case the university, makes a single transaction with the transit authority. This can reduce line-ups at ticket booths, ease access to transit and reduce costs from multiple transaction operations. Also, in most cases, the students' university ID card becomes the transit pass. This enables the agency to save on printing costs of tickets and passes. Moreover, making every student enter with a pre-paid pass will ease access to transit and can potentially reduce boarding times. Another advantage of university-based programs comes from the fact that students – more often than other transit users – use transit more frequently outside peak hours (Meyer and Beimborn, 1998). This particularity brings down the operating cost of routes serving the university as students fill unused capacity. The following benefits relate to more internal or administrative concerns, and are harder to quantify.

As the selling of a monthly transit pass ensures the agency with revenue for the whole month, U-Pass revenues are perceived for even longer periods, usually for a whole semester. This large sum is gathered before the service has been provided, which can also contribute to simplify financial operations. Here, the payment scheme resembles that of a store offering its customers to take possession of a good right away while paying for it in several payments. In our case, roles are reversed and the transit agency holds the advantage: users pay the full price up-front while the service for which they have already paid for will be provided throughout the semester.

Last but not least, the following point describes possible outcomes from increased ridership. A study by Brown, Hess and Shoup (2001) surveyed U-Pass programs at 35 universities and revealed that increases in student transit ridership ranged from 71 percent to 200 percent for the first year of the program and that growth continued at a rate between 2 percent to 10 percent per year the following years. Although the literature is unanimous on the fact that U-Pass programs do increase student ridership, the pricing scheme of the U-Pass does not enable it to claim that more ridership means more revenues. Once again, the pricing scheme between the university and the agency is meant to break even, not make more revenues on the back of students. For example, Meyer's study (1998), effectively describes the case of the MCTS, Milwaukee's transit agency, that had to increase service on routes serving the university. Since this was due to the implementation of the U-Pass, and the students and university would be the ones benefiting from the added service, it is not a surprise that they would cover the additional cost. In fact, in order for the agency

to break even, U-Pass fees had to be raised. This being said, ridership increases will not generate revenue benefits *per se,* but will generate external benefits through service improvements. Indeed, service improvements make for increased quality and quantity of transit by making buses more frequent, by adding more routes or express services, and by extending hours later at night and on weekends. Even more so, these improvements hold the potential to increase the number of riders who will pay the full fare and thus might increase revenues. Other advantages of increased transit ridership include increased bus efficiency, reduced operating cost per ride, and reduced dependence on government subsidies (Brown et al., 2001). Finally, participation in such a program constitutes a highly valued and highly positive publicity for the transit agency.

2.7.4. For the community

Additional transit services made to accommodate an increase in ridership strongly benefits regular users who will have more frequent bus service. In addition, these added services can help attract new users outside of the university context who will switch to transit but pay the regular fare price. Aside from cost reduction, U-Pass may have an important impact on daily commuting time for not only participants in the program but the whole community as more cars are taken off the streets, resulting in significant overall time savings. Benefits induced are those commonly associated with a reduction of traffic on any set infrastructure. Wear of streets and roads is lessened by the reduction in the number of cars, and congestion, commuting time and air pollution may also decrease. Students at the university level have a positive impact on the quality of life of the community in which they reside. Cities where a large number of students are found (such as Boston or Montreal) enjoy an

active art scene and a large array of specialized services. This contributes to the economic activity of the community, and as the transportation system allows students to spread more evenly away from the main campus, benefits reach further in the community. Other benefits include: increased safety and tranquility of residential neighborhoods around campus and similarly to other parties involved, it provides positive visibility and marketing to the city.

Table 3 Recapitulative table of benefits

U-Pass benefits	
For students	For the institution
• Offers a viable and attractive travel option • Reduces transportation costs (up to 94% reduction off regular fares) • Increases accessibility to more distant, lower-cost housing and employment areas • Makes it easier for occasional users (e.g. students in residence) to run errands • Increase of transportation equity • More time & money allocated to studies instead of supporting a car • Offers a safe travel option for those who consume alcohol • Provides a reliable transport alternative for all in case of adverse weather conditions	• Reduces demand for parking • Reduces expenses associated to car infrastructure • Reduces demand for student residences • Opportunity gain in terms of campus layout and planning. Enables use of land for buildings or greenspace, rather than parking • Supports overall objectives to reduce auto travel and GHG emissions • Provides excellent visibility for the university • Helps recruit and retain students
For the community	For the transit authority
• Reduces pressure on local roads • Increases safety and tranquility of residential neighborhoods around campus • Lower air pollution • Service improvements due to increased student ridership benefits non-student users • More diversity in the community as more students reside in the city • Improve image of the city	• Guaranteed revenue • Ridership grows on poor-performing evening and mid-day routes • Puts forward a good image for the company • Ridership gains help fill empty seats on buses • Ridership gains allow for increased subsidies • Ridership gains increase publicity revenues • Students more likely to use transit after they graduate

Adapted from U-pass toolkit, The complete guide to universal transit pass programs at Canadian colleges and universities, 2004.

2.8. Disadvantages

Despite the fact that advantages are numerous, there are also some disadvantages.
A first weakness comes through the process of implementation itself, since negotiations can be long and laborious before all parties agree on the costs of the program and contribution expected from each.

It is stated that the largest constraint for universities depends on whether they can find support from student associations while imposing tuition fees and often increasing parking fees as well (Hester, 2004). Naturally, efforts will be greater if the university relies entirely on student contribution to cover the costs. On the contrary, if the university subsidizes the entire cost of the program, efforts to convince members are no longer necessary, and the high cost the university must now ensure becomes the main disadvantage (Hester, 2004).

For the transit authority, benefits can greatly fluctuate. As mentioned previously, a determining factor is the amount of service present on the routes that will be served. Although ridership increases are associated with revenue increases, here, new riders use buses at a highly discounted rate that does not ensure added revenue. Rather, ridership increases may require additional buses that might represent a cost that will not be recovered (depending on the university/agency contract) and reduce the agency's cost per rider efficiency on certain lines. The agency must also anticipate the need to deploy measures to prevent abusive pass use, such as sharing. As mentioned by Hester (2004), this

requires preparation of a strategy and the improvement of administrative attention and personnel training.

For those students who continue to use the car or active modes such as biking or walking, disadvantages take the form of equity concerns, especially when the program is mandatory. On the other hand, opt-out programs require students to pay a higher price, thus reducing the attractiveness of the program and its benefits. The environmental justifications should easily outweigh opposition of non-users.

2.9. What comes out of all this?

To summarize, advantages considerably outweigh the disadvantages and success stories have been reported coming from various contexts. Brown, Hess & Shoup's 2001 study highlights the results of implementing Unlimited Access programs in 35 universities throughout the United States. Although these programs were offered in very different settings - from small towns to large cities and small (4,500) to large size (49,000) student bodies - they noted that transit ridership increases ranged from 71 percent to 200 percent during the first year. Undoubtedly, universities have proven to offer the ideal settings for such programs to be successful.

Other than the fact that universities constitute a large basin of population with a common destination, two major contributing elements stood out of the literature. First, the governance is simple as it involves only the transit agency and the university rather than having various entities to coordinate like in a community setting. Second, the university

controls both its land use and parking availability, which simplifies the adoption of complementing incentive and disincentive measures (Senft, 2005).

2.10. Previous comparable research

As shown in the previous sections, studies on the subject cover distribution of costs and appropriation of benefits amongst the different players. They provide useful evaluations of success rates of university pass programs. However, few studies have focused on market segmentation and none have been published using a quantitative approach aimed at improving an existing program, as it is the case in this report. A close example comes from Meyer and Beimborn's study, where segmentation charts were used to better understand transit market capture rates for University of Wisconsin-Milwaukee's students. Their evaluation was based on information such as: proximity to transit services, simple or complex trip patterns, class schedules, and full or part-time employment. Results indicate that the person most likely to use transit lives near transit, has complex trip patterns and is a day/evening student.

3. RESEARCH DESIGN

In this report, we seek to identify what factors have acted as incentives for Université de Sherbrooke's students to use public transit instead of a private vehicle. A test using data obtained from the 2005 university-wide survey is performed using Random Forest (RF) classification method.

The analysis focuses on students who switched from using a car to public transportation after the implementation of the U-Pass program and on those who did not switch modes. Outputs of the modal choices before and after the program implementation were translated into a dummy variable serving as the dependent variable for two separate analyses. The first relates to student profile information, while the second covers student opinion on transport issues. The objective of this study is to better understand past usage and impacts of the transit pass program in order to improve the current transit modal share, as well as to help other universities interested in implementing a similar program estimate their potential success rate.

We begin with a brief overview of the area before explaining the conditions that led to the implementation of Université de Sherbrooke's U-Pass program in 2004. We then describe data source and methodology used to conduct our analysis.

3.1. Case study: Université de Sherbrooke

3.1.1. Context

Located in the southern part of the province of Quebec, the city of Sherbrooke is part of the *Estrie* administrative region. It is the 6th largest city in the province with a population of 154 800 inhabitants. Its universities and colleges, in both French and English, welcome over 40 000 students in total of which 75 percent come from outside of town, and employ some 11

000 people[4]. Altogether, the 8 educational institutions form the Sherbrooke University hub, which is informally known as the "student city" with the largest concentration of students in Quebec. For every 100 inhabitants, 10 are students, whereas Montreal has 4 students per 100 inhabitants[5].

By itself, the Université de Sherbrooke has about 35 000 students of which 85 percent come from other cities. It employs 5 600 people of which 3000 are professors that represent 10 percent of Quebec's total university professors. The university is divided into three campuses. For the purpose of this study we will only cover students attending the main campus located in the southern edge of the city, and the health campus located at the eastern edge of the city. The third campus, located in the city of Longueuil, a suburb of Montreal, is not eligible to the U-Pass program.

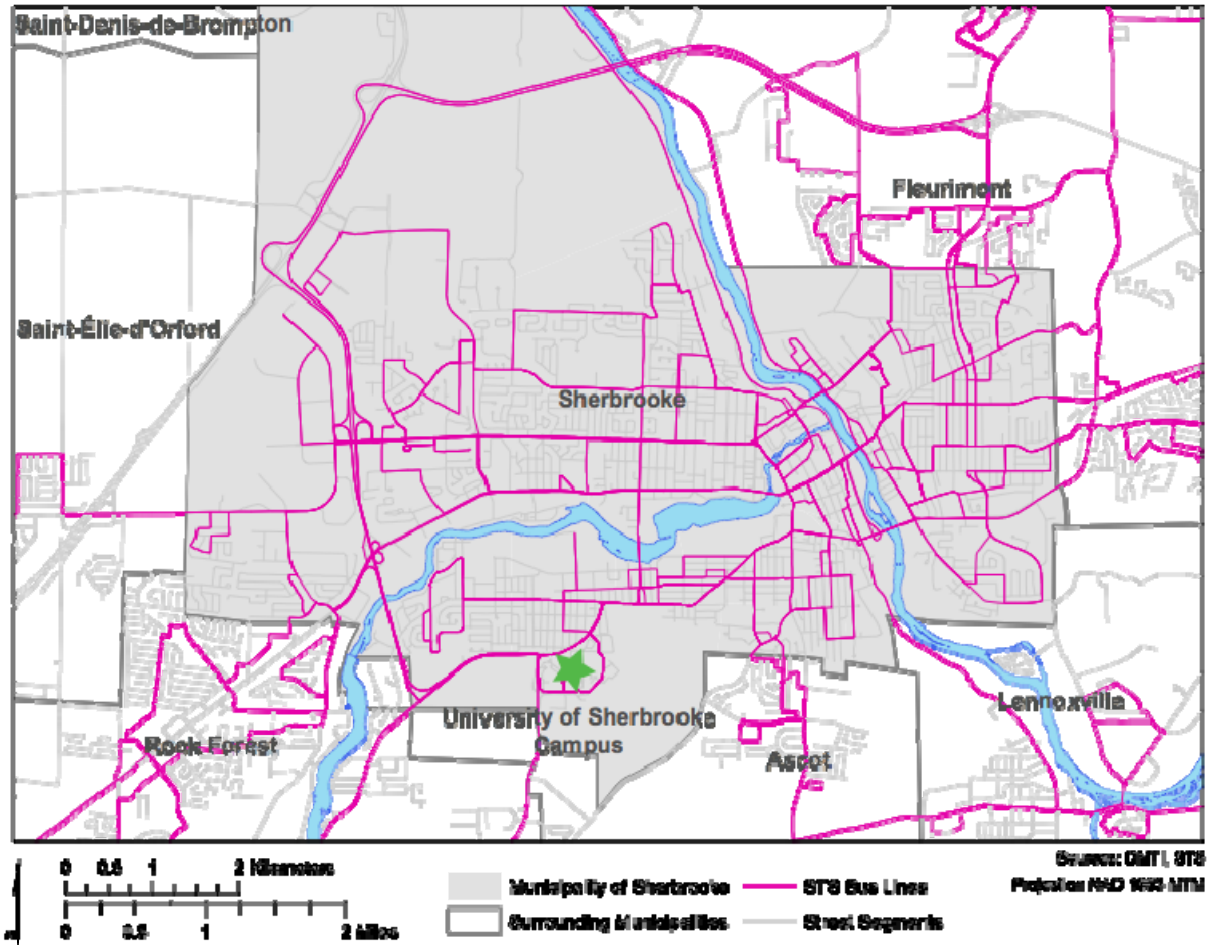
The Société de transport de Sherbrooke is the transit authority for the city. It operates 34 lines that cover a territory of 366.4 kilometers[6] (as shown in Figure 1). The STS estimates that about 50 percent of its clientele is composed of students (FEUS, 2003).

[4]www.ville.sherbrooke.qc.ca/webconcepteur/web/VilledeSherbrooke/fr/ext/nav/vieetudiante.html?iddoc=97394

[5] ibid

[6] www.sts.qc.ca/

Figure 1 Map of Sherbrooke and STS's bus lines



3.1.2. Problematic of the Université de Sherbrooke

This section describes how the Université de Sherbrooke was brought to consider the U-Pass and how it implemented the program. Sherbrooke's university transit pass program prides itself on being the first U-Pass program in the province of Quebec while offering the highest transit discount for cities of 150 000 inhabitants within Canada.

In 2003 the university's student federation (Fédération étudiante de l'Université de Sherbrooke) produced a comprehensive report entitled "Le transport en commun à

Sherbrooke" to further encourage students to use public transit, and to convince prospective students to choose the city of Sherbrooke for their studies. This document presented the current situation of public transit services in the city, as well as transport issues faced by students and a list of improvements to be made. Their main concern was to support the creation of a discounted transit pass for all students without age restriction. In the same year, their request was granted and students could ride transit at an advantageous rate no matter their age. This achievement would serve as a crucial first step towards implementing the U-Pass program. A good dialogue was established between the university and the STS, where transit issues were put at the forefront of university concerns. Also, this measure came as recognition, from the transit authority, that students were price-sensitive users. Because they have less disposable income than others, students are part of a specific market segment, thus making their demand more price elastic.

Meanwhile, UdeS was facing serious parking issues as the student body was increasing at a rate of about 4 percent each year while transit service was decreasing. In 2003, demand for parking was such that cases of delinquent parking were common. According to Alain Webster, vice-principal of the University's sustainable development office, drivers were seen parking their cars on the lawn around buildings, on sidewalks, and even staircases. With the waiting list for parking permits increasing, an investment needed to be made for the construction of additional parking. Instead, officials decided to act differently, even though, contrary to other more centrally located universities, UdeS had land available, which meant a lesser cost to build surface parking if needed. However, the university was not at its first attempt to resolve the parking issue on campus, and to avoid

facing the same problem in another five years they decided to approach the situation differently by changing their perception of the problem. In this sense, building additional parking was compared to 'building your way out of congestion' or to what Lewis Mumford once said: "*adding highway lanes to deal with traffic congestion is like loosening your belt to cure obesity "*. Indeed, the problem no longer resided in the lack of parking spaces but in the fact that there were too many drivers.

Revenues related to transport and transport infrastructures generally come from governmental subsidies at the ministry of education. Parking infrastructure is not eligible to these subsidies, leaving the university responsible to cover expenses regarding construction, maintenance and management of its parking. It was estimated in 2005 that the unit cost per surface parking space was of 4 000$ and 30 000$ for underground parking (Rajotte, 2005). In addition, building parking encourages car use and takes up a lot of space, which would have contradicted with its new sustainable approach.

UdeS explored other university policies regarding transportation such as: increasing parking charges; banning students (or certain students such as undergraduates) from bringing cars to campus; adopting an active marketing strategy to promote existing transport alternatives or build additional infrastructure; and improving existing services. All of these alternatives were left out as they only seized one aspect of the problem: to discourage car use or to encourage the use of transit. None of these avenues had the integrated approach the university sought. Moreover, the approach it was looking for would become the "*fer de lance*" of its sustainability program (called Plan vert). This program

consisted in reducing its GHG emissions, increasing overall efforts towards recycling, fostering community involvement and ensuring a sustainable growth of its campus. As transportation underlies most of these goals, it became obvious they needed to directly tackle the transit problem. The university settled on the U-Pass as it had proven elsewhere to reach the goals they had set themselves.

3.1.3. Presentation of the program:

Similarly to other reviewed programs, each student enrolled at the university received a new student ID card that would serve as their transit pass, giving them access to an unlimited number of rides by bus in the territory covered by Sherbrooke's transit authority.

When the U-Pass program was introduced in 2004, the University agreed to pay 100 percent of the bill for a period of 5 years at a cost of 865 000$. Usually, since both the university and the students benefit from this measure, the cost is generally split between the two (Brown et al., 2001). UdeS justified its choice by the fact that it greatly simplified the implementation process (University law claims that any additional student fee higher than 15$ must be submitted to a referendum[7]). Moreover, promoting free and unlimited access to transit for all students helps to maximize the success rate of the U-Pass, and is equally effective as an aggressive promotional campaign to encourage the use of buses.

As it was mentioned previously in the literature review, UdeS paid the STS the equivalent amount to what the transit authority earned prior to the program, from students riding the bus. In addition, this amount was indexed each year to reflect the increases in labor costs

[7] Webster, Alain, Personal Communication, December 8th 2010.

and gas prices as well as costs related to adjusting the service to meet increasing demand. Similarly to most universities, UdeS partly subsidized its U-Pass through parking fare increases. The other part came from their budget in the hope they could later rely on federal and provincial subsidies as well as publicity or sponsorship revenues to assume these costs. The money never came, and because of financial difficulties UdeS had to cut part of the funding. Also, since it could not rely entirely on parking fees, they had to revise their mode of paying the cost of unlimited access, which had reached 1.3 million by 2009.

"Abolishing the program was never an option" said Alain Webster (Vice-Principal of Sustainable Development). Instead, the university reached out to students and engaged an open debate to find a solution on how to split the costs. The 1.3 million would now be split equally and adjusted, like most other programs, based on the number of students registered at the university.

Since 2009, the transit authority along with the university negotiated the value for all students to have unlimited access to transit at a cost of 55.80$ per semester per full-time student. The STS charges a smaller amount (39.76$) for part-time students as they use transit less often. These charges are now equally divided between the university and the students. As shown in Table 4, the later now have an out-of-pocket cost of only 27$ per semester. Students who previously paid the regular monthly transit pass at the rate of 62.50$ for the 4 months of a semester (4 x 62.50$ = 256$), the U-Pass represents an 89.5% discount.

Table 4 Cost of taking transit before and after the U-Pass

	Cost/Semester Without U-Pass	**Cost/Semester With U-Pass**
Students	256$	27$
University	0	28.80$
TOTAL	256$	55.80$

Source: Société de transport de Sherbrooke, June 2011.

Because students were used to the U-Pass to be entirely free, UdeS officials felt they had to lower student contribution to a minimum in order to ensure the continuing success of the program. In this sense, the university's contribution was mandatory, along with the adoption of a universal coverage scheme. With these efforts combined, they managed to offer the second cheapest U-Pass program in the country (see Table 5).

Table 5 Student contribution to U-Pass programs across Canada

List of Canada's U-Pass programs (covering areas less than 150 000 inhabitants)

Area	Province	Post-Secondary Institution	Student Contribution / Semester
Kingston	ON	Queens University "Bus-it" Pass	15 $
Sherbrooke	**QC**	**Université de Sherbrooke**	**27 $**
Kingston	ON	St Lawrence College	33 $
Thunder Bay	ON	Lakehead University	35 $
Fredericton	NB	St Thomas University	38 $
Kelowna (BC Transit)	BC	University of British Columbia Okanagan	50 $
Guelph	ON	University of Guelph	56 $
Niagara	ON	Niagara College	63 $
St Catharines	ON	Niagara College	63 $
Welland	ON	Niagara College	63 $
North Bay	ON	Nipissing University	66 $
North Bay	ON	Canadore College	66 $

Niagara	ON	Brock University	73 $
St Catharines	ON	Brock University	73 $
Sudbury, Greater	ON	Laurentian University	73 $
Welland	ON	Brock University	73 $
Strathcona	AB	Grant MacEwan College	95 $
St Albert (StAT)	AB	University of Alberta	95 $
St Albert (StAT)	AB	Grant MacEwan College	95 $
Strathcona	AB	University of Alberta	95 $
Peterborough	ON	Trent University	118 $
Ottawa	ON	University of Ottawa	145 $
Thunder Bay	ON	Confederation College	195 $

Adapted from Association canadienne des transports urbains (ACTU), rapport 2008

Since the beginning of the program in 2004, the university subsidizes the U-Pass through its parking fees. This aspect not only enables the university to find sufficient funding to offer the U-Pass, but as we explained, it also influences the transfer of car users towards transit. Parking rate increases help lower the price of public transit, which makes it more attractive while drivers receive a disincentive as they are forced to pay for a second transportation option.

Parking prices at UdeS have increased for students and employees. Student's contribution help pay for a part of the costs of providing unlimited transit access while employees - who have yet to gain access to the U-Pass - help finance the university's sustainable development strategies such as composting, using reusable dishes, etc.

3.1.4. Outcomes of the U-Pass

In the winter term of 2005, 5 months after the implementation of the program, the university conducted a university-wide survey in order to assess the impact on student mode choice. Data from the survey show a considerable change in student modal share since the adoption of the U-Pass[8].

Bus use increased by an impressive 31 percent – the 31% solution of our title – which made the bus responsible for more than half (57 percent) of student's trips to UdeS. Most importantly, this variation of 120 percent means the car has been surpassed by public transportation as the dominant mode[9]. As shown in Table 6, most of the new transit users were previous car users who switched to taking the bus. Other students who switched were mostly pedestrians but also cyclists and taxi users.

Table 6 Variation of modal share before and after the adoption of the U-Pass

Transport mode	**Before** adoption of U-Pass (n=2129)	**After** adoption of U-Pass (n=2579)	Variation %
Bus	25.9% (n=551)	57.0% (n=1469)	120%
Car (driver)	34.6% (n=736)	19.0% (n=489)	-45%
Car (passenger)	6.2% (n=131)	1.5% (n=38)	-76%
Cycle	1.6% (n=34)	0.7% (n=17)	-56%
Walk	30.1% (n=643)	21.7% (n=560)	-28%
Taxi	1.6% (n=34)	0.1% (n=6)	-63%

Source: Rajotte, 2005

[8] These results relate mainly to full-time students, who represent a 95 percent proportion of the sample of this study.

[9] In order to better understand the real impact of the U-Pass on student travel behavior presented in the table here above, newly registered students were withdrawn from the sample.

For the university, the new distribution of modal share was very encouraging as it implied a series of other underlying benefits.

a. Reduction in vehicle kilometers traveled and GHG emissions

According to Rajotte (2005), the average distance covered by a student traveling to university by car is 7.8 kilometers. With this information, and with an estimate of students who left their cars at home (1900), we were able to calculate a reduction of 148 200 kilometers traveled to UdeS on a weekly basis[10]. For one academic year (28 weeks), the implementation of the U-Pass allowed to save 4 149 600 vehicle kilometers traveled to UdeS.

It is important to note that with a 19.5 percent drop in car use for non-university related trips, total benefits incurred should be much higher. We must also add that reducing the amount of kilometers traveled by car reduces chances of accident and increases the quality of life for neighborhoods adjacent to the campus.

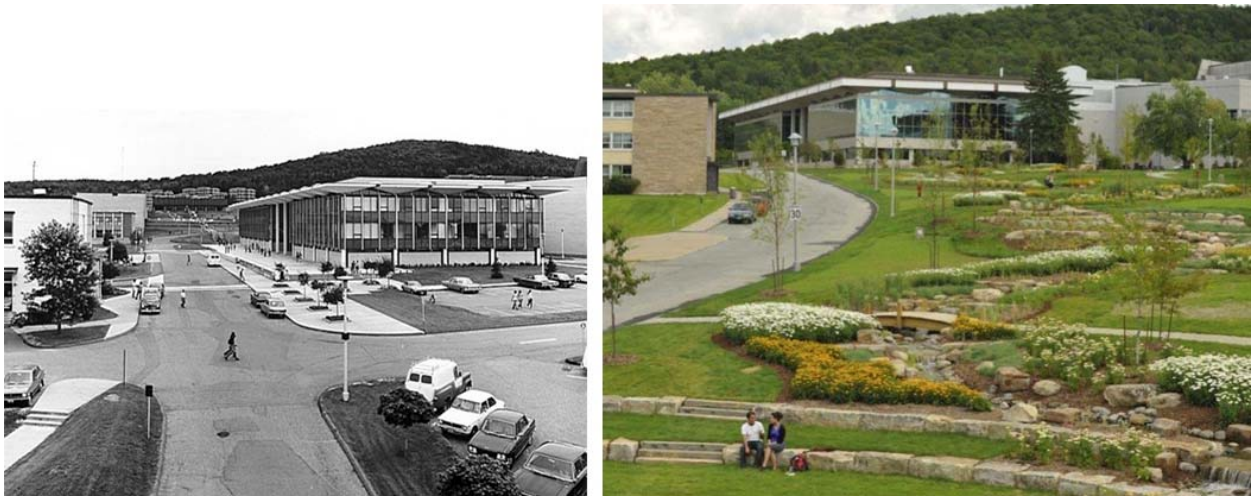
Based on the number of kilometers saved, we calculated a yearly diminution of green house gas emissions of 1 053 tons by using a conversion rate of 254 grams (g) of GHG per person-km (PK).

[10] This number is calculated based on the average kilometers by an average number of trips per week multiplied by the number of students that have switched (7.8km x 10 x 1900)

b. Impact on parking

The reduction in car users by 39% allowed the university to cancel building additional parking facility on campus and contributed to reduce parking permits sold in 2005 by 977. This important reduction in demand allowed the university to close down a 1000 unit parking lot, although the number of students increases each year. Parking citation revenues dropped consequently. This loss in revenue was mitigated by the savings evaluated at 85 000$ in maintenance (Rajotte, 2005). Figure 2 shows the old centrally located parking that was converted into a pedestrian oriented green space. This measure was part of a new planning approach that consists of relocating car activity from the center of the campus to its periphery. Moreover, the current parking offer easily accommodates the demand for parking so much so that parking is now prohibited on campus roads and a moratorium was instated on building additional parking.

Figure 2 A parking lot that was converted into a green space in 2009



e. Reduced housing demand pressure in periphery of the campus

The U-Pass also encouraged a better integration of students with the broader Sherbrooke community as easy commuting allows students to find cheaper housing further away from campus.

In all, combining economic, social and environmental goals, the U-Pass allowed a modal transfer from the car to a more respectful mean of transport, which led to physical and social improvements of the university's environment.

In the region, the university's initiative and success story became an example for others to start a similar program. Both the city's collegial level institution and the Hospital Center adopted their own discounted pass programs. Also, in the province of Quebec, the Université Laval in the city of Quebec is currently working on implementing a program for their students while the Université de Montréal just announced the start of its pilot project for the fall of 2011. Undoubtedly, there is an interesting dynamic happening where transportation issues are being addressed differently.

UdeS is currently studying the possibility of broadening the program to faculty and staff members. However, since transportation subsidies are an additional income, the federal government will most likely tax this added benefit. If so, it may limit the success of extending the program, with the result of significantly diminishing its advantages.

The second part of this paper presents a more in-depth analysis of the results obtained from UdeS's U-Pass. It will focus on new transit users but also on remaining car drivers as they represent potential switchers.

3.2. Data source

The data used in this paper originated from the survey conducted by the Université de Sherbrooke in 2005. UdeS provided the data file as well as the questionnaire. The questionnaire was sent through the university's internal e-mailing system to a list of all students enrolled in the winter term of 2005 (about 25 000 students). Only students enrolled in the satellite campus of Longueuil, 150 kilometers from Sherbrooke, were excluded as their geographical location makes them ineligible to the U-Pass. In order to gather information on the modal share and traveling habits of students before and after the implementation of the U-Pass, the survey was sent at the end of the winter term, 5 months after the start of the program. The questionnaire contained a total of 39 questions and took on average 15 minutes to complete depending on the respondent's profile. Students were asked to provide profile information (age, sex, student status, place of residence, etc.), current and pre U-Pass travel habits (mode, distance, commute time, etc.) as well as opinions on STS services and improvement measures regarding traveling to UdeS using all transportation modes. Although the response rate was very satisfactory, participating respondents totaled only 2 percent of part-time students, who collectively represent 51.5 percent of the total student population. For this reason, this study focuses on full-time students. With 2671 respondents the survey has a representative sample of full-time

students with a low margin of error (± 1.92 percent) and a level of confidence of 95 percent, 19 times out of 20[11].

3.3. Methodology

First, a selection of the variables available (95 in total) was made to keep only those related to the goal of this study. Consequently, information on a specific mode such as the three most frequently used bus lines for trips to UdeS and non-university related trips pertaining to the before and after period were discarded. They contained many missing responses that weakened the accuracy of the analysis. In the same manner, we also left out variables that excluded a majority of respondents. Therefore, information on transport services between the main campus and the health campus is only relevant for medicine and health sciences students. Finally, variables regarding a specific intra-urban bus company had to be left out for privacy matters. In the end, we were left with 46 variables either related to student profile (16) or to student opinion regarding transportation issues (30). Also, survey entrees of students who were not enrolled in both terms before and after the introduction of the program were incomplete and therefore excluded from the analysis. In total, 2091 entrees remained, of which we extracted all car drivers for the before period based on whether or not they switched to transit in the after period. Accordingly, 846 entrees were analyzed. The purpose is to compare dominant characteristics of students who switched from car to transit after the implementation of the U-Pass with those who did not switch.

[11] Alain Rajotte, "Diagnostic Du Transport De Personnes À L'université De Sherbrooke," in *Université de Sherbrooke: L'Observatoire de l'environnement et du développement durable* (Sherbrooke: Université de Sherbrooke, 2005).

We used the Random Forests (RF) algorithm (Breiman, L. (2001). "Random forests." Machine Learning 45(1): 5-32) as implemented in R (R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.) as the package randomForest (A. Liaw and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3), 18--22.). A key advantage of RF for this given study is its capacity for robust analysis of data sets composed unlikely of discrete variables, with other cited advantage of "(1) very high classification accuracy; (2) a novel method of determining variable importance; (3) ability to model complex interactions among predictor variables" (Cutler, 2007). RF uses decision trees as a predictive model to classify – in order of importance – the main variables that explain the dependent variable. The RF algorithm uses bootstrap aggregating (or bagging) to randomly select a set of predictor variables, which are then assigned a score based on the frequency of their presence in the model, increasing the robustness. For our research, this method is particularly helpful at distinguishing which variable is worth addressing through our descriptive analysis. The RF method will enable this by classifying all 46 variables in order of their strength from the most influential to the least influential at predicting student travel habits.

In transportation research, binomial logistic models and multivariate regressions are the most commonly used techniques to identify characteristics that affect travel behavior of a group of individual. Data collected from the university wide survey contained no continuous variables. Continuous variables are essential in a regression model either as the dependant variable or in large numbers as independent variables. For this reason, a

different statistical method capable of running a similar analysis was chosen. Random Forests (RF) is a relatively new method in the field of statistical classification. It is more often used in machine learning and biology where it has proven to be a strong analytical tool.

RF was applied to the two previously mentioned groups of variables: variables relating to student profiles and those relating to student opinions. Analysis of the "profile" group provides us with detailed information on two subgroups by identifying who are the remaining car drivers (non-switchers) and who are the new transit users (switchers). More importantly, it highlights in order of importance, the determining variables responsible for encouraging students to switch modes. This information will help create a list of typical characteristics of students that are more likely to switch and help make a U-Pass program successful. This list can be used to estimate potential switchers in other university contexts using student profiles. Similarly, profile variables of those who did not switch will help the university properly aim its marketing campaign towards reluctant students. This additional information can consequently reduce costs of advertising while increasing the success rate of the U-Pass.

On the other hand, analysis of the "opinion" group provides input from both switchers and non-switchers regarding preferences on current and new transportation measures. Variables include opinions on current STS services, improvements to the transit system, transportation to UdeS, as well as restrictive measures regarding car use and green house gas reduction measures. University officials and the transit agency can use this

information to better understand criticism expressed by remaining car users (non-switchers) on the transit service. Non-switchers represent the student subgroup for which officials are most interested in as they represent the remaining potential switchers. Understanding the reasons why they did not switch and their opinion regarding possible improvements to transportation at UdeS is crucial. It represents a valuable source of information that can help define the content of a marketing strategy to promote the use of transit. It is also useful in deciding which course of action to follow when investing in new transportation measures.

In addition, summary statistics in the form of bar charts were produced to help interpret and complete results obtained from the RF analysis.

4. ANALYSIS

The first part of the analysis was made using profile variables. These variables relate to questions that help identify who the students are, based on age, gender, place of residence, and faculty. Other variables used relate to travel habits, such as accessibility to a car, distance to university, and commute time to university.

4.1. Profile variables

4.1.1. Factor importance

Figure 3 Random Forests output of important profile variables

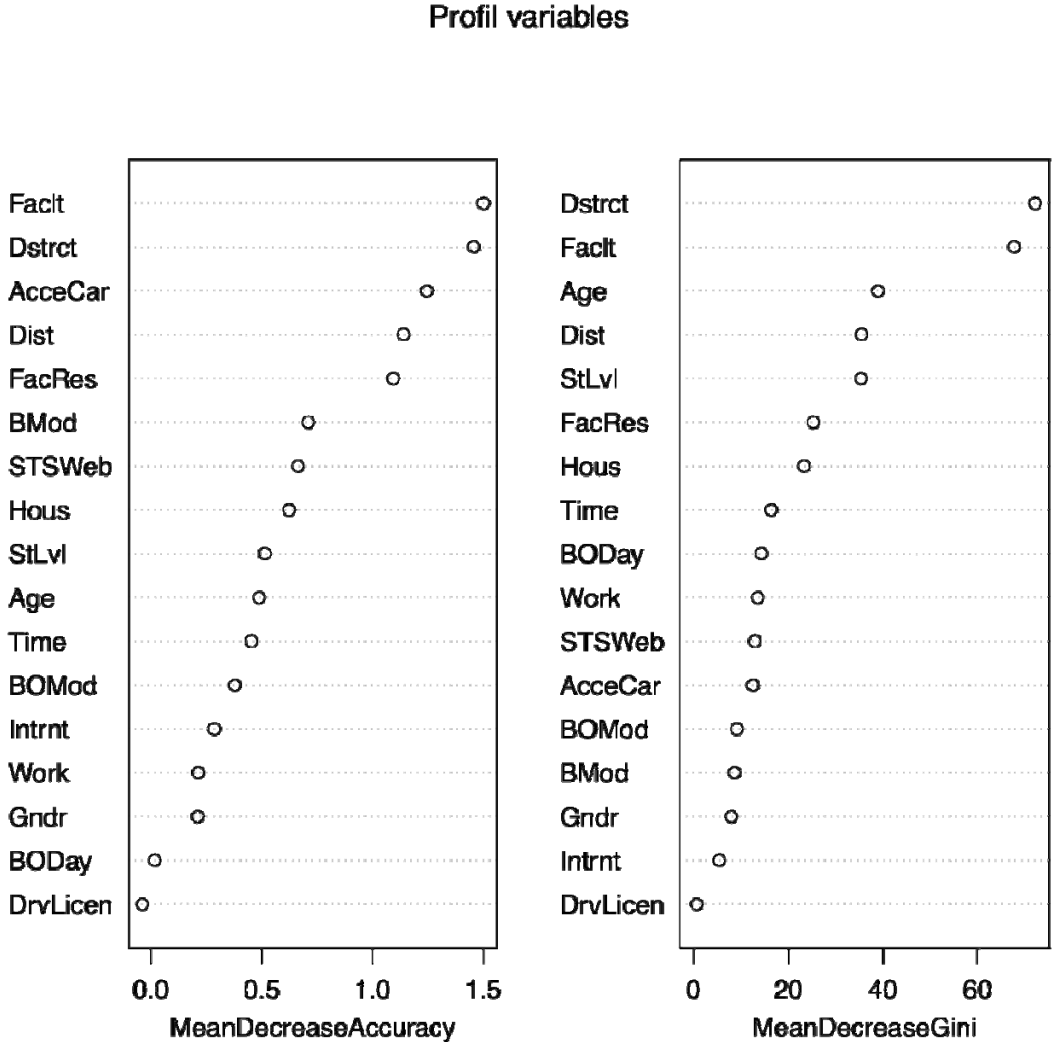


Table 7 Table of translated profile variables

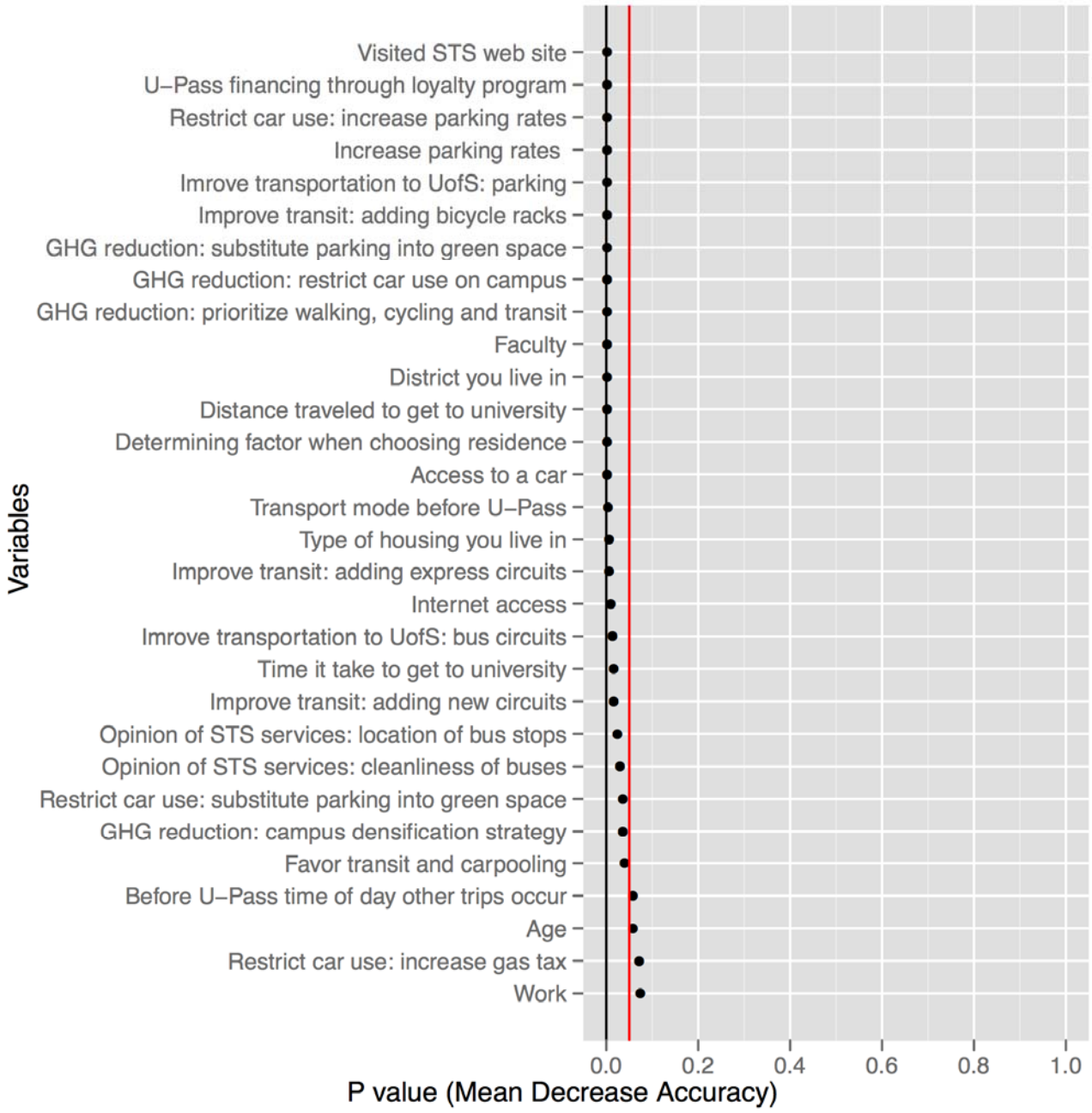
Variables	Description
BMod	Transport mode before U-Pass for university trips
BOMod	Transport mode before U-Pass for other trips
BODay	Before U-Pass time of day at which other trips occur
FacRes	Determining factor when choosing place of residence
Time	Time it takes to get to university
Dist	Distance traveled to get to university
Gndr	Gender
Age	Age
Work	Work
Dstrct	District in which the student currently lives in
Hous	Type of housing the student currently lives in
Intrnt	Internet access
STSWeb	Visited STS's web site
DrvLicen	Valid drivers license
AcceCar	Access to a car
StLvl	Level of studies
Faclt	Faculty
Dependent variable	Dummy variable for switching from car to transit

Output from the Mean Decrease Accuracy (MDA) plot presents the results from the RF analysis for all profile variables. The gaps between MDA values of certain variables fluctuate according to their predictive capability and naturally formed distinctive groups. A high predictive value means a high predictive effect.

Complementary to this, a second analysis was made in order to provide statistical support to the results above. P values from permutations (shown in Figure 4) present the frequency in percentage at which the output value of random analyses is as large or larger than the

data above. In other words, it verifies the consistency of the results by classifying all statistically significant variables under the 0.05 MDA mark.

Figure 4 P values from permutations

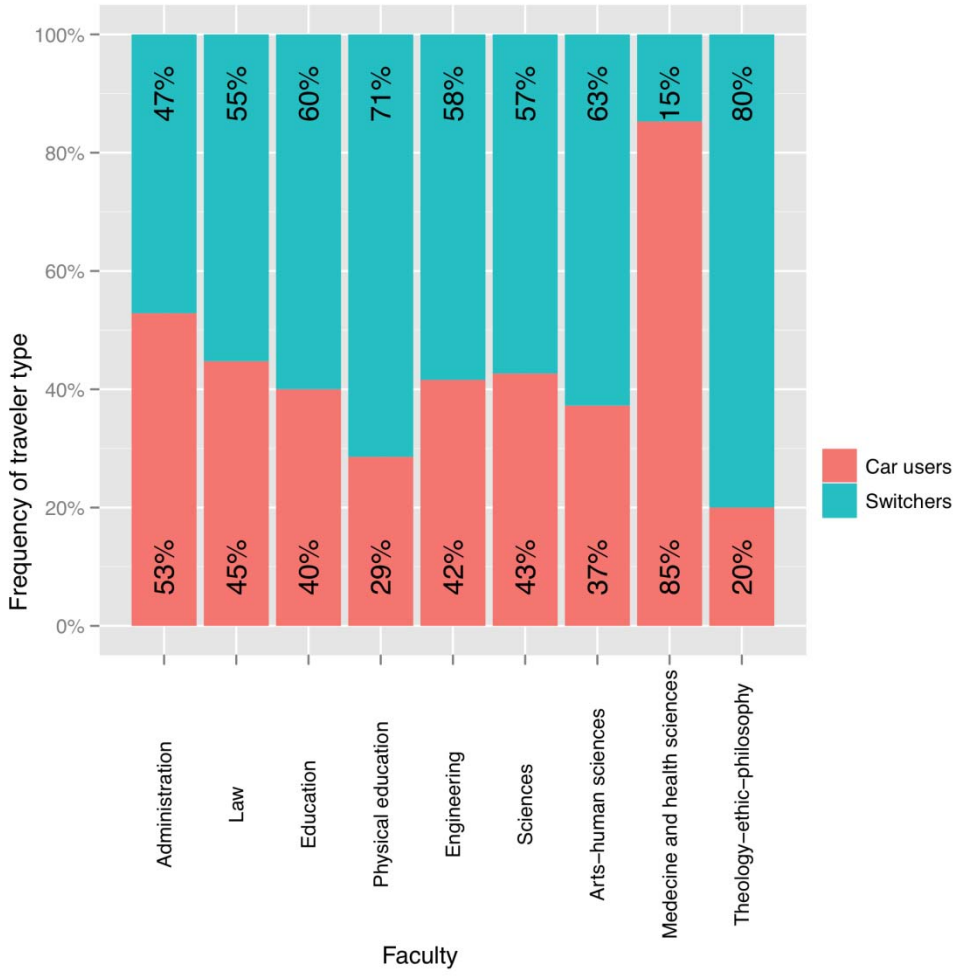


Based on the output of important profile variables (Figure 3), our analysis will concentrate on the first five variables as their MDA sets them apart from other predictive variables and since their p values show statistical significance (Figure 4).

The faculty in which students are enrolled in is the most important variable for distinguishing between those who switched modes from those who did not switch (Figure 5). A look at the corresponding summary statistics provides more in-depth explanation.

4.1.2. Summary statistics

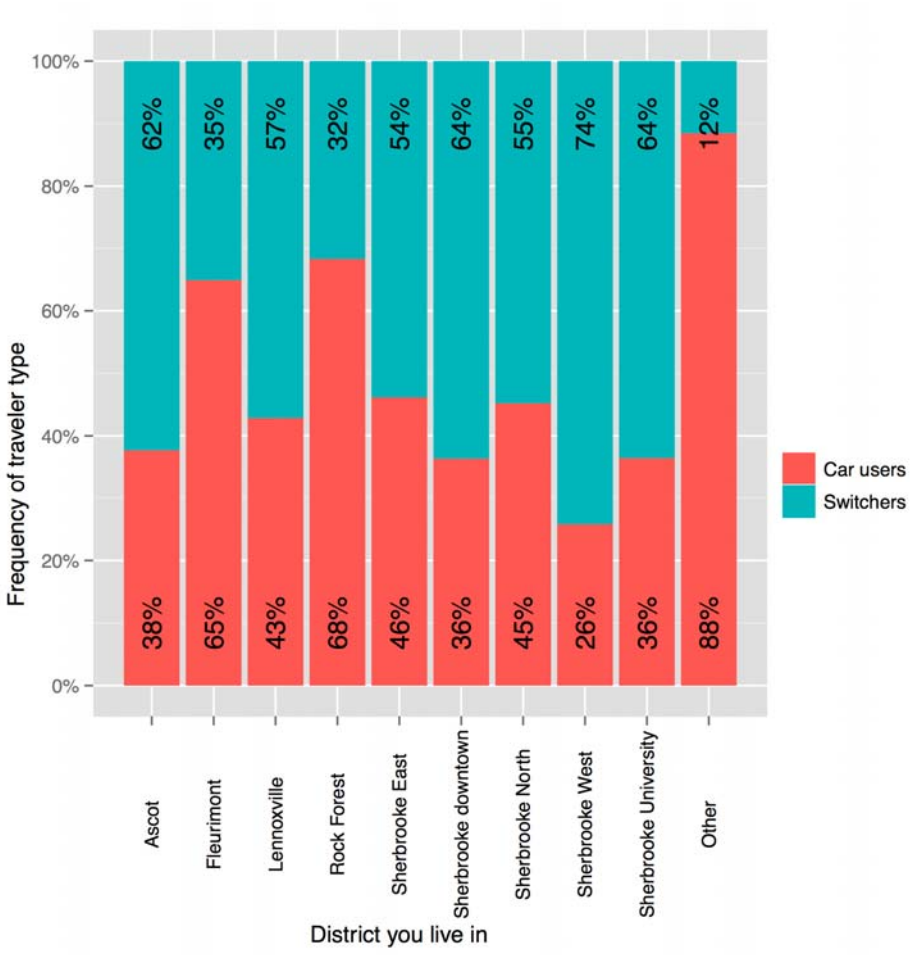
Figure 5 Descriptive chart of "faculty" variable



What strikes at first is that students in the medicine and health sciences faculty show a very high propensity to continue to use the car for their university-related trips prior to the implementation of the U-Pass (about 85%). The second faculty with a higher percentage of non-switchers is the administration faculty with 53%. The remaining faculties all have more switchers than not. Students in theology and philosophy have the highest tendency to switch to public transit (80%) followed by the sports and physical education faculty (71%) and the arts and human sciences faculty (63%).

A possible explanation why the RF method has classified the "faculty" variable as the strongest predictive value could be that the field we study in is a reflection of our interests. Intrinsically it is related to our values and those promoted by the job it will result in. This variable is therefore loaded with important elements that identify dominant traits of UdeS students. As for the medicine and health sciences students, one can only presume that they must alternate between their classrooms and health centers in the area, which requires numerous trips on a presumably tight schedule. In addition, late shifts require a degree of flexibility that public transit has difficulty achieving in low frequency, off-peak hours. As for the physical education students, it would fall into character for them to use a transportation mode that requires more physical activity.

Figure 6 Descriptive chart of "district" variable

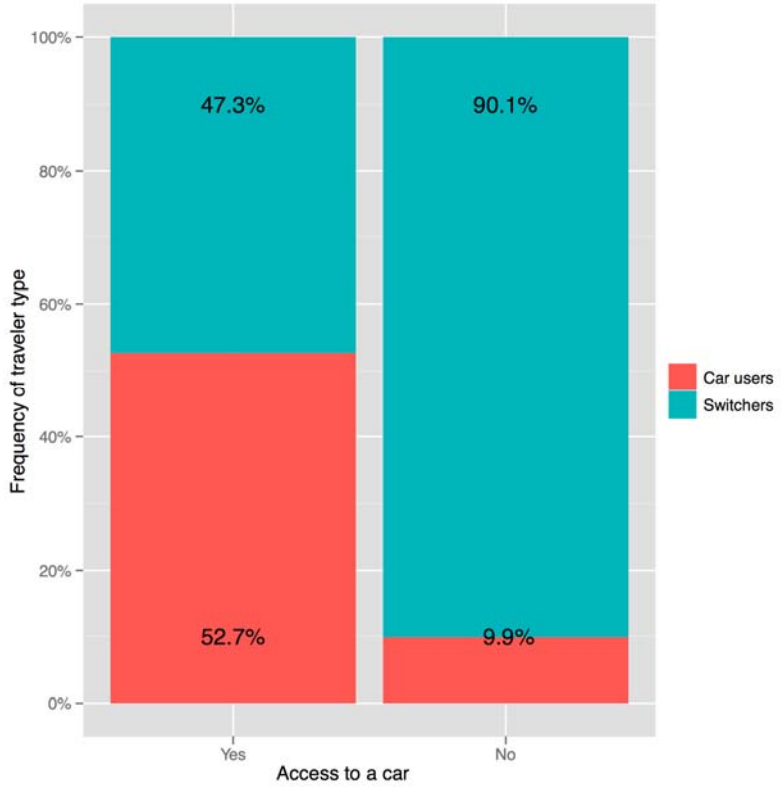


The following variable relates to the district in which students live. This variable has a high predictive value as it correlates with other influencing factors such as distance, time of travel, and public transit service. Our hypothesis is that car modal share will increase as distance and time increases and as public transit service decreases. Figure 5 confirms this hypothesis by portraying a distinct tendency for districts further away from the university to have less switchers; amongst them, Rock Forest (68%) and Fleurimont (65%). Referring back to Figure 1 of the map of Sherbrooke, this tendency can be explained by both the distance and a lower availability of bus service to get to the university. All remaining districts are located closer to the university and benefit from higher bus frequency;

accordingly, they all have a higher proportion of switchers. Residents from Sherbrooke West, Université de Sherbroke district, and the Downtown district show the highest proportion of switchers. At the other end of the spectrum, the "other" category relates to districts that are far from the university and outside STS's service area, hence the 88 percent rate of non-switchers.

This variable is of particular interest for the transit authority as it provides clues on whether or not the bus service to the university is adequate based on the rate of attraction of comparable districts.

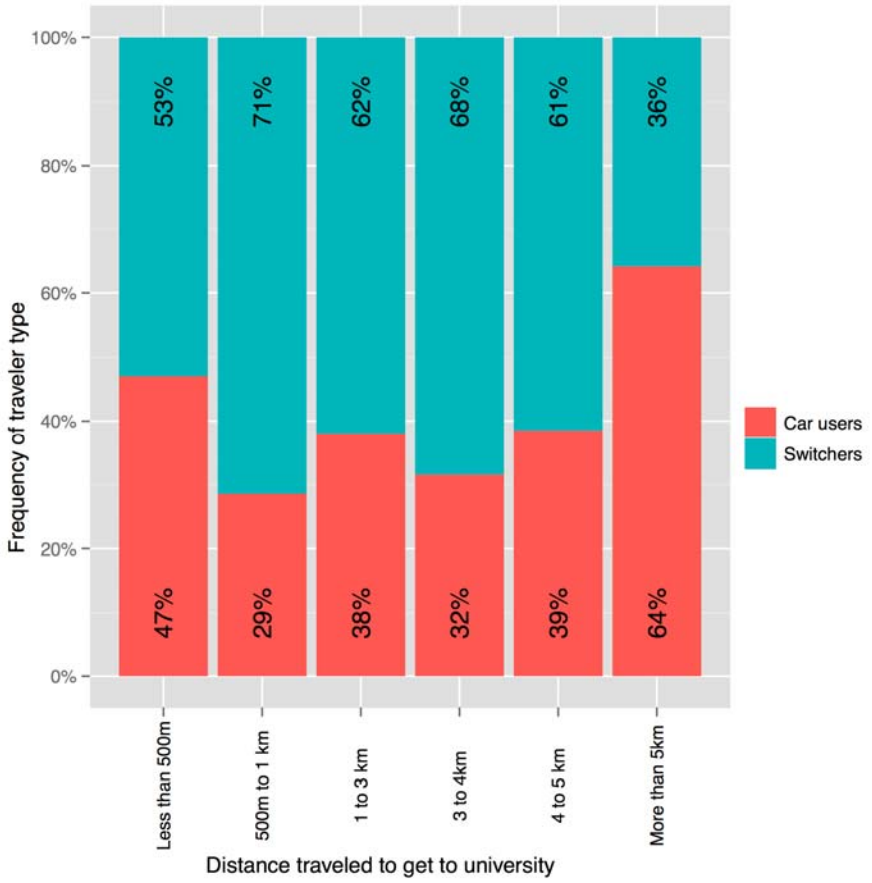
Figure 7 Descriptive chart of "car access" variable



Accessibility to a car is the third most important variable. Whether students have access to their own car, their parent's or their partner's, the accessibility to a vehicle

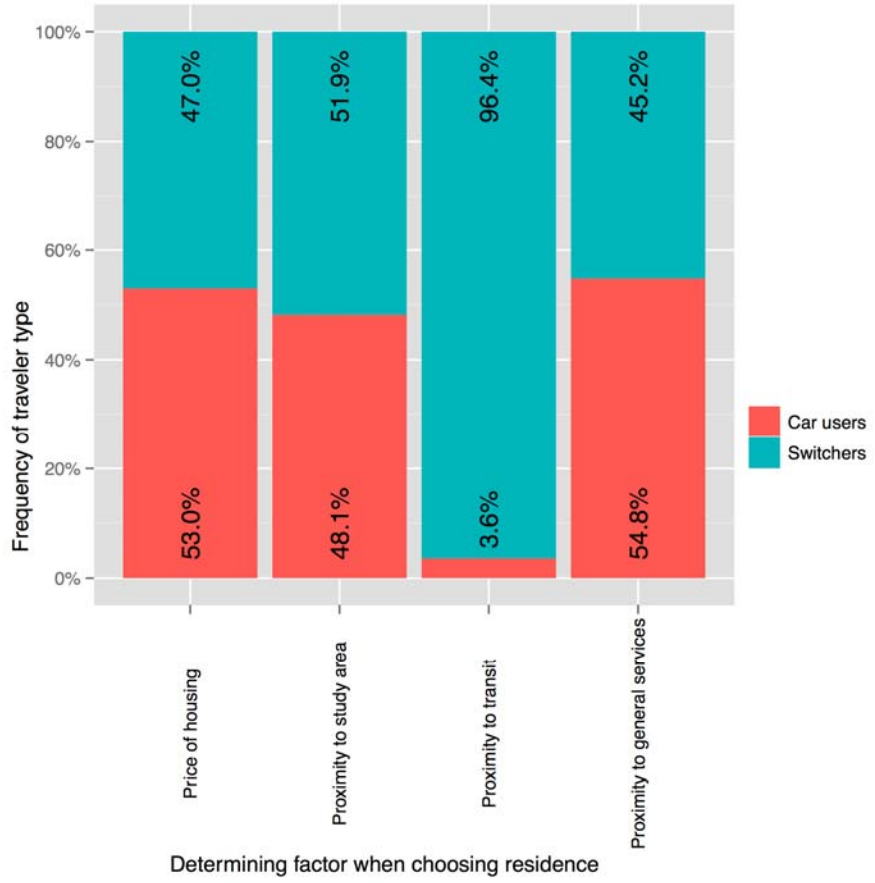
increases their probability of being non-switchers. At the opposite, 90 percent of students who do not have access to a car responded very favorably to the U-Pass and switched to transit. Students who have access to a car but decided to switch nonetheless have a high chance of being previous passengers who now benefit from increased autonomy in their travel needs. This hypothesis was reinforced by an interesting underlying fact as we observed that passengers have a higher tendency to switch (71%) compared to drivers (47%). Accordingly, the corresponding variable (Before mode or BMod) is relatively high in the list of predictive variables. Finally, it is possible that non-switchers who answered they do not have access to a car (10%) are also vehicle passengers. They do not have access to a car as a driver, but the car remains their primary mode of transportation.

Figure 8 Descriptive chart of "distance" variable



Categorical answers available for this question offer detailed information on student travel behavior for up to 5 kilometers. Above this, the last category (More than 5km) is too broad and offers very little analytical opportunity. For future surveys, the use of an open-ended question should be prioritized to show the precise distance at which the U-Pass loses its attractiveness (this can also be applied to the "time" variable). In such a case, both "distance" and "time" variables would be expected to show higher importance levels in the mean decrease in accuracy output. Nonetheless, compared to the "district" variable, the short intervals of distance provide additional details on the relationship between switchers and distance. At the opposite of what we would expect, 47 percent of students living less than 500 meters away from the university still use their car. We must be cautious when interpreting the results, as two thirds of respondents live more than 5 kilometers away from the university. Further, the general trend seems to indicate that students living closer to the university tend to switch more easily to transit.

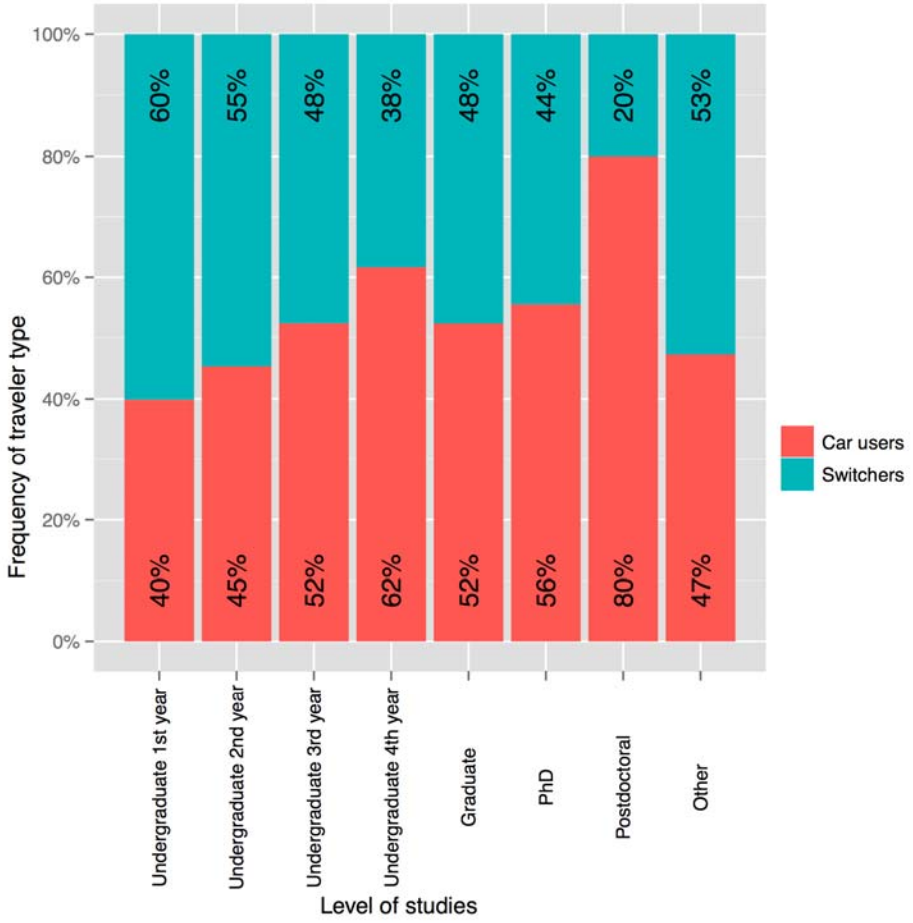
Figure 9 Descriptive chart of "facRes" variable



When asked: "What is the determining factor when choosing your place of residence?" with no surprise, the vast majority of respondents answered the "Price of housing" with a slightly larger number of non-switchers. Respondents may be inclined to choose this answer as it does not relate to any proximity factor as opposed to the three remaining answers. However, it is interesting to note that non-switchers (55%) value their proximity to general services more than switchers (45%), whereas switchers value their proximity to transit (96%) and to their study area (52%).

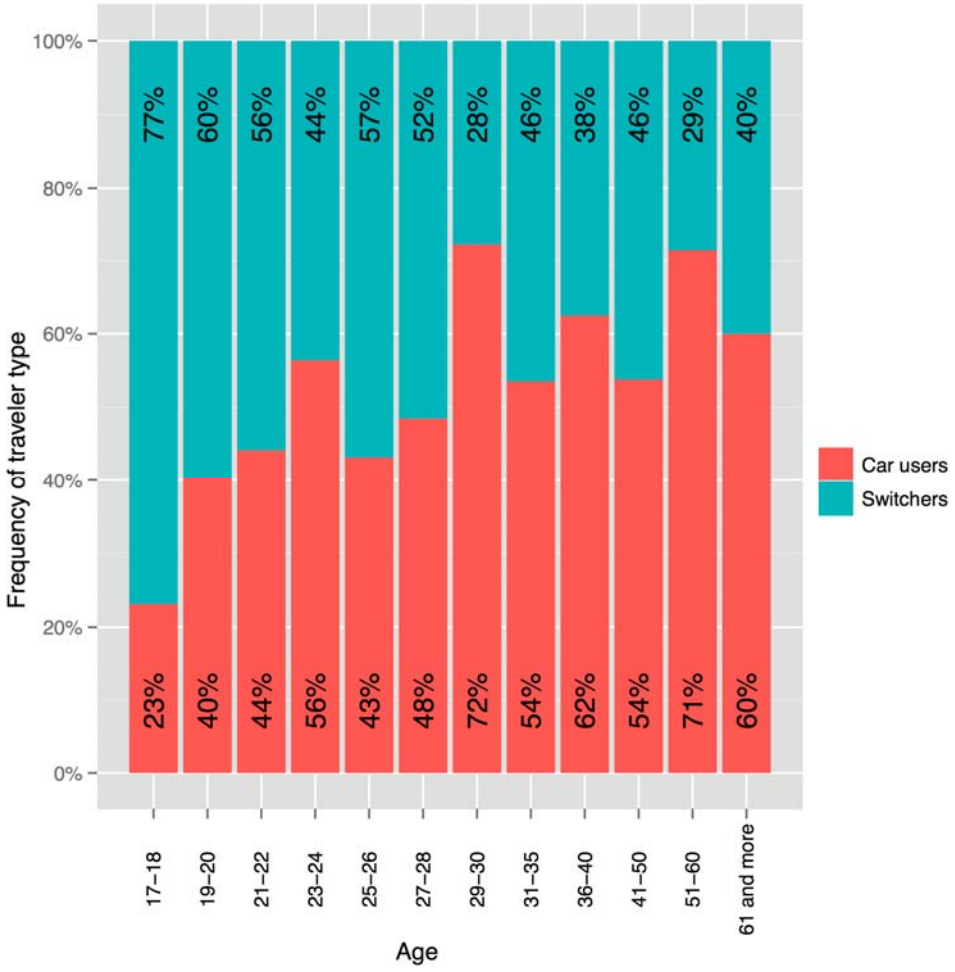
The RF analysis shows that the following variables have a strong predictive value (Figure 3), however, the "p value from permutations" (Figure 4) shows no statistical significance for these variables. Their effect in predicting a student's tendency to switch is unimportant and consequently must be excluded when estimating potential switchers. Nonetheless, for the task at hand, these variables contain interesting information to characterize the profile of switchers and non-switchers at UdeS.

Figure 10 Descriptive chart of "student level" variable



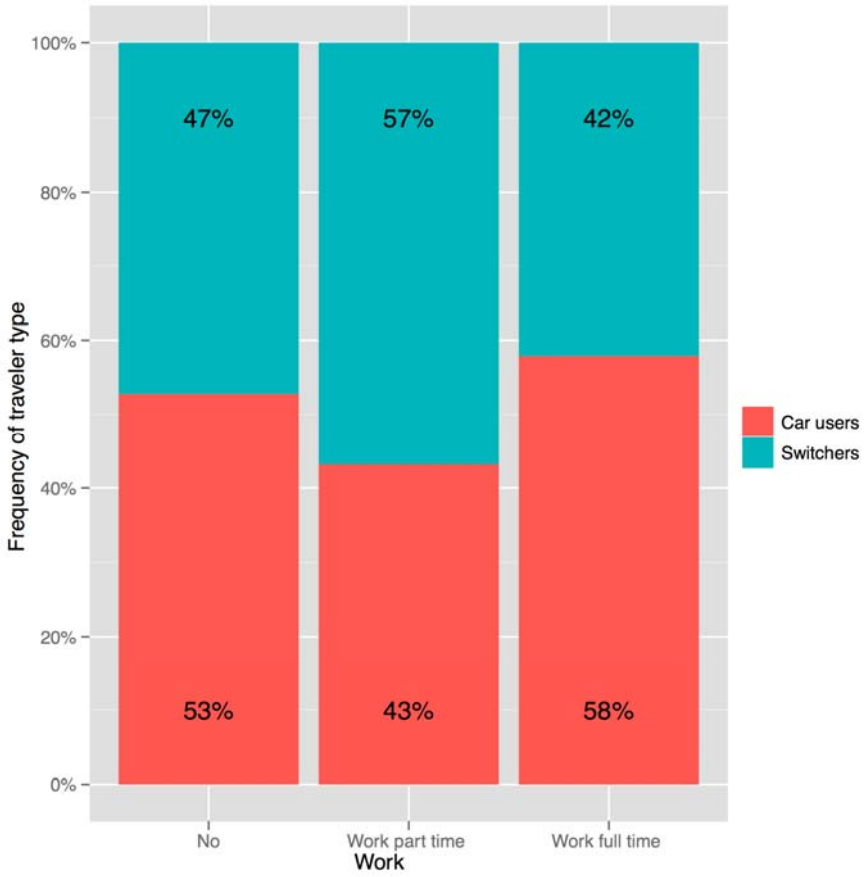
Another interesting predictive variable is the level of studies. Figure 10 shows an increase in the number of non-switchers as students get further in their level of studies. Nonetheless, undergraduate students in first and second year are more likely to be attracted by the U-Pass program and switch to transit (respectively 60% and 55% switchers). The number of non-switchers becomes dominant at the third year (52%) and this number further increases in the fourth year (62%). A drop occurs in the categories of graduate and doctoral students but they remain mostly car users (respectively 52% and 56%). Finally, postdoctoral students show a very high propensity to remain car users, as 80% of them did not switch. As students in higher levels of education tend to be older, this variable is correlated with age, explaining why the observations are similar. Therefore, we can also affirm that student levels corroborate with the likelihood of having children and a certain decrease in ability to change travel habits.

Figure 11 Descriptive chart of "age" variable



It is interesting to note the bar chart shows a gradual increase in non-switchers as the age of students increase. In summary, the majority of students 28 and younger – with the exception of 23-24 year olds – are more inclined to switch, whereas the majority of students 29 and older tend to continue to use the car. A possible explanation lies in car ownership, which rises with the increase of age of students. The car represents a travel option they have already paid for, which increases the likelihood of them using it. Another possible explanation, as mentioned previously, is that older students have a higher probability of being parents, and it is known that households with children tend to use a car more often.

Figure 12 Descriptive chart of "work" variable



The "work" variable shows the majority of workers generally switch and non-workers tend to remain car users. A closer look at Figure 12 shows a differential effect between part-time and full-time workers. Part-time workers are more attracted by the U-Pass measure, as 57 percent have switched to transit compared to 42 percent for full-time workers. A more in-depth analysis revealed that part-time workers are usually full-time students who prioritize their studies while the job provides revenues for daily expenses. The 56$ per month discount offered by the U-Pass has a great value to them as it represents the equivalent of 6 work hours at the current minimum wage. By contrast, full-time workers tend to be part-time students (59%). Similarly to the two previous variables, the

age of full-time workers can be a determining factor, decreasing their chances of taking transit.

The RF analysis has provided valuable information by classifying opinion variables in order of their predictive power to switch or not to public transit. Out of the 16 opinion variables, we were able to concentrate our analysis on the 5 most important variables (faculty, district, access to car, distance and determining factor when choosing residence) and the 3 that provided both a significant predictive value and high analytical opportunities (student level, age and work). The remaining 8 variables highlighted by the RF model are weaker predictive variables meaning their effect over switching is smaller. Nevertheless, they can provide UdeS officials with more details on who the switchers and non-switchers are and are therefore presented in the Appendix.

In summary, students that are more likely to switch to public transit have the following characteristics in common, in order of importance:

- Study in theology, ethics and philosophy, physical education or human sciences;
- Live relatively close to UdeS;
- Do not have access to a car;
- Chose their place of residence based on proximity to transit or their study area;
- Were passengers prior to the U-Pass;
- Are in their first and second year of undergraduate studies;
- Are 28 years of age and younger;
- And are part-time workers.

In contrast, those who are not likely to stop using their car:

- Study in medicine, health sciences and administration;
- Live relatively far from UdeS;
- Have access to a car;
- Chose their place of residence based on proximity to services;
- Were drivers prior to the U-Pass;
- Are in their third and fourth year of undergraduate studies or are graduate, doctoral or postdoctoral students;
- Are 29 years of age and older;
- And are non-workers or full-time workers.

4.2. Opinion variables

Our second part of the analysis was made using opinion variables. These variables relate to questions asking students what they think of the current service provided by the STS, as well as prioritizing measures that aim at improving their travel needs. Results from the Random Forests will allow university officials to organize their actions regarding transportation investments in order of importance to expect a maximum of positive outcomes. Further, results from the descriptive statistics give additional information on who the switchers and non-switchers are.

4.2.1. Factor importance

Figure 13 Random Forests output of important opinion variables

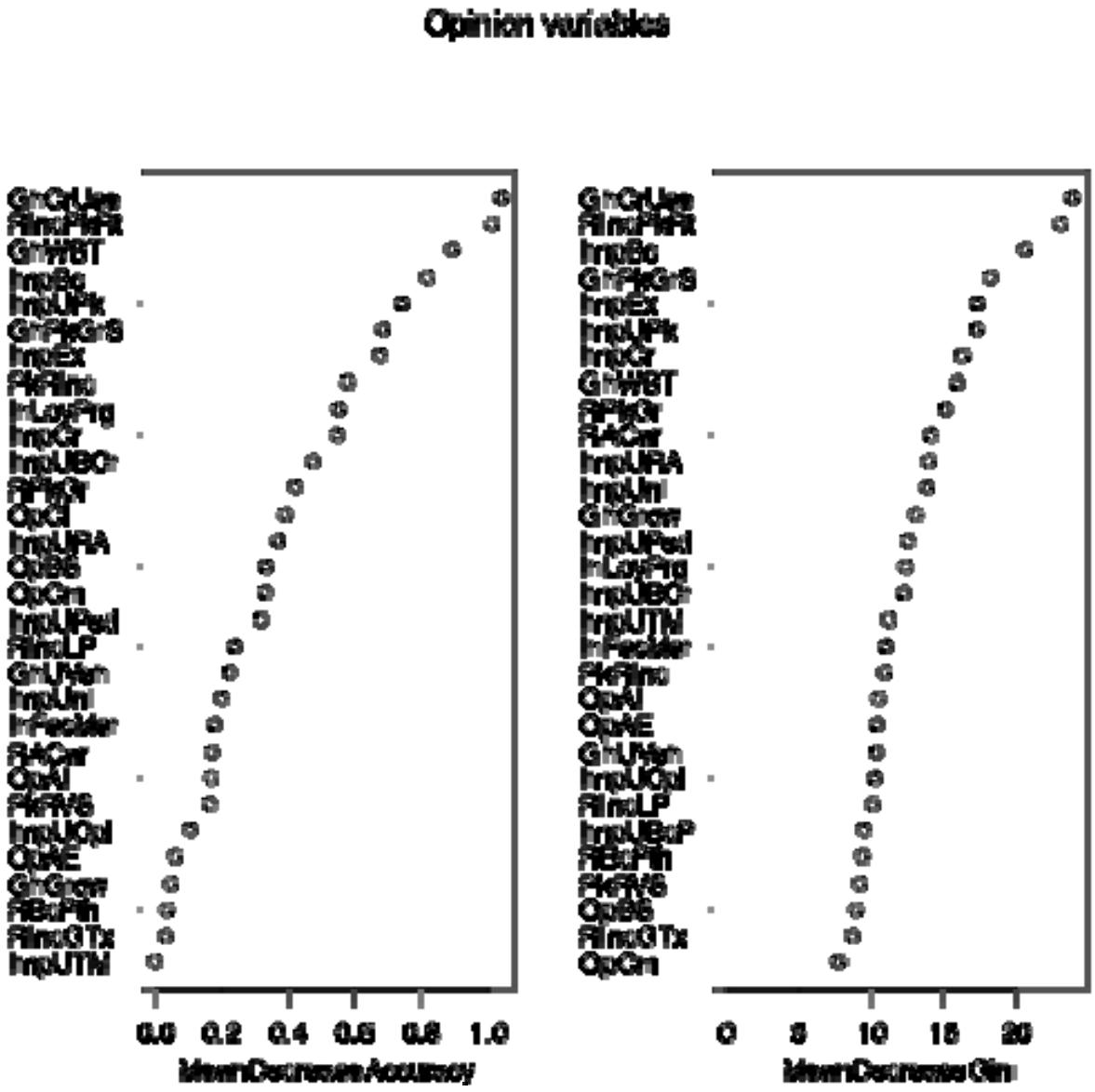
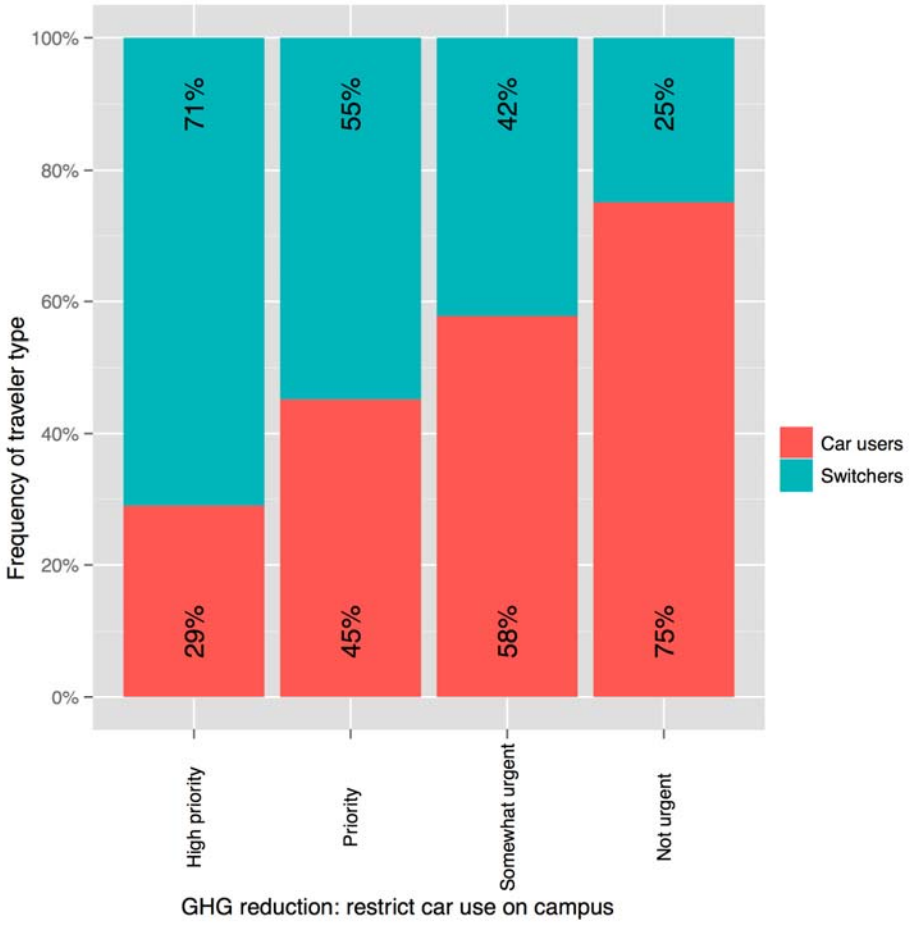


Table 8 Table of translated opinion variables

Variables	Description
OpCl	Opinion of STS services: cleanliness of buses
OpCm	Opinion of STS services: comfort of buses
OpBS	Opinion of STS services: location of bus stops
OpAE	Opinion of STS services: auxiliary equipment
OpAI	Opinion of STS services: access to information on schedules
ImpUnl	Improve transit: spread U-Pass to others
ImpCr	Improve transit: adding new circuits
ImpEx	Improve transit: adding express circuits
ImpBc	Improve transit: adding bicycle racks
ImpUPed	Improve transportation to UdeS: pedestrian paths
ImpUBcP	Improve transportation to UdeS: bicycle paths
ImpUBCr	Improve transportation to UdeS: bus circuits
ImpUCpl	Improve transportation to UdeS: carpooling
ImpURA	Improve transportation to UdeS: road access
ImpUPk	Improve transportation to UdeS: parking
ImpUTM	Improve transportation to UdeS: multimodalism
RIncPkRt	Restrict car use: increase parking rates
RPkGr	Restrict car use: substitute parking into green space
RBcPth	Restrict car use: bicycle paths on roads of campus
RACar	Restrict car use: reduce private vehicle allowance
RIncLP	Restrict car use: increase license plate cost
RIncGTx	Restrict car use: increase gas tax
InFscMsr	Favor transit and carpooling
InLoyPrg	U-Pass financing through loyalty program
PkRVS	Parking rates in relation to vehicle size
PkRInc	Increase parking rates
GhUVeh	GHG reduction: electric university vehicle
GhCrUse	GHG reduction: restrict car use on campus
GhPkGrS	GHG reduction: substitute parking into green space
GhWBT	GHG reduction: prioritize walking, cycling and transit
GhGrow	GHG reduction: campus densification strategy
Dependent variable	Dummy variable for switching from car to transit

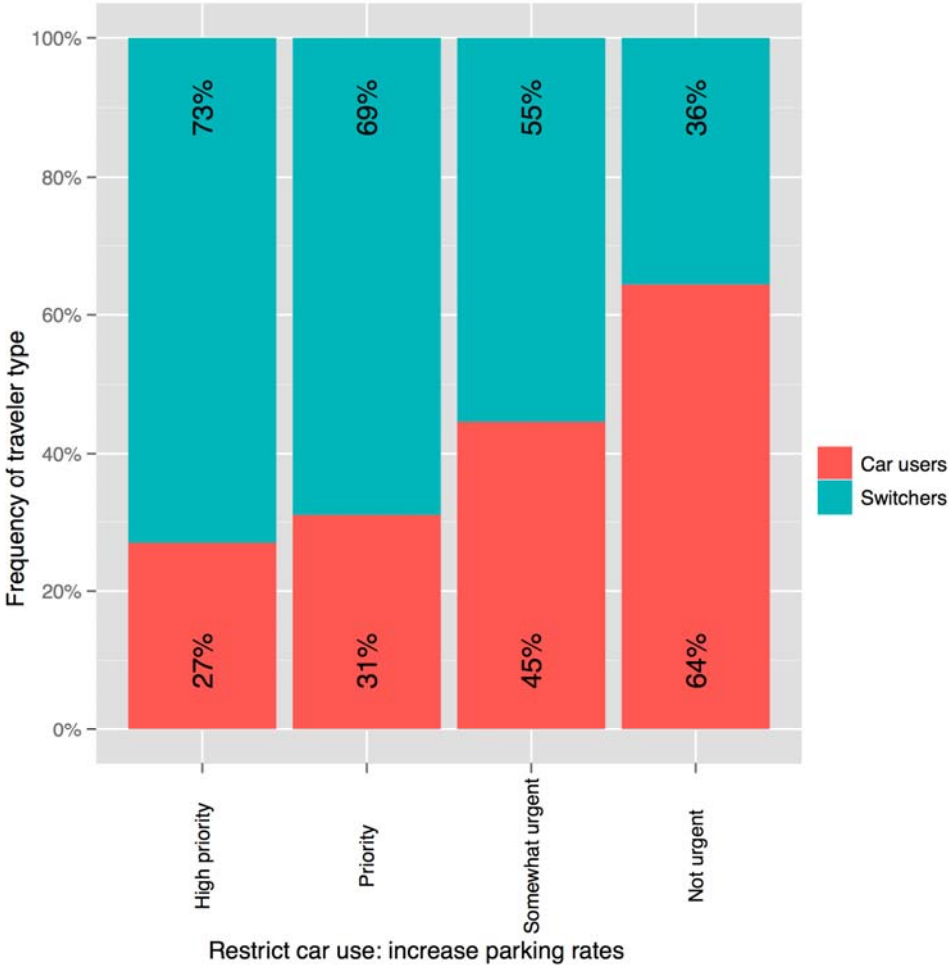
4.2.2. Summary statistics

Figure 14 Descriptive chart of "GhCrUse" variable



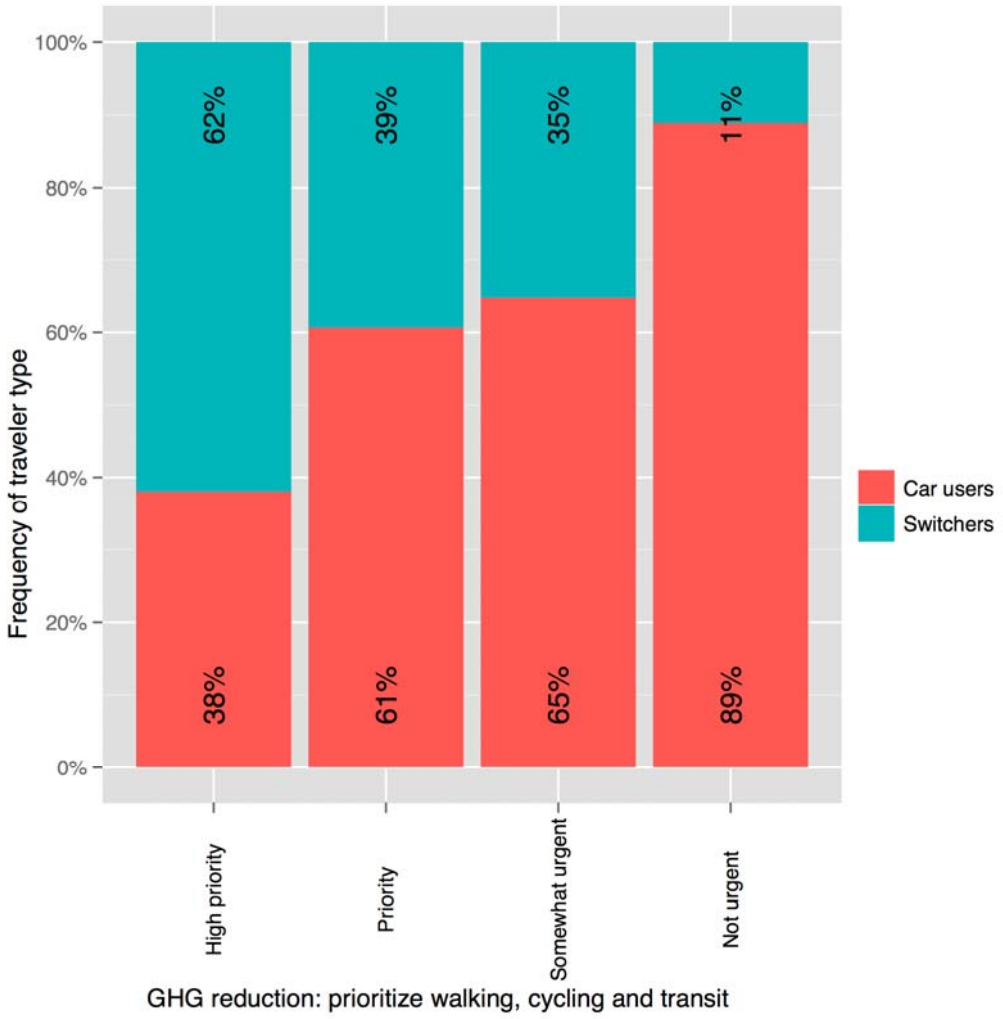
The RF analysis shows a clear dominance in the mean decrease in accuracy score for the first two variables. The chart above shows a clear interest from switchers to restrict car use on campus in order to reduce green house gas emissions while non-switchers generally do not prioritize this measure. This result does not come as a surprise. Nevertheless, the high discrepancy between car users and new transit users can be used to the advantage of university officials to both retain switchers and dissuade car users.

Figure 15 Descriptive chart of "RIncPkRt" variable



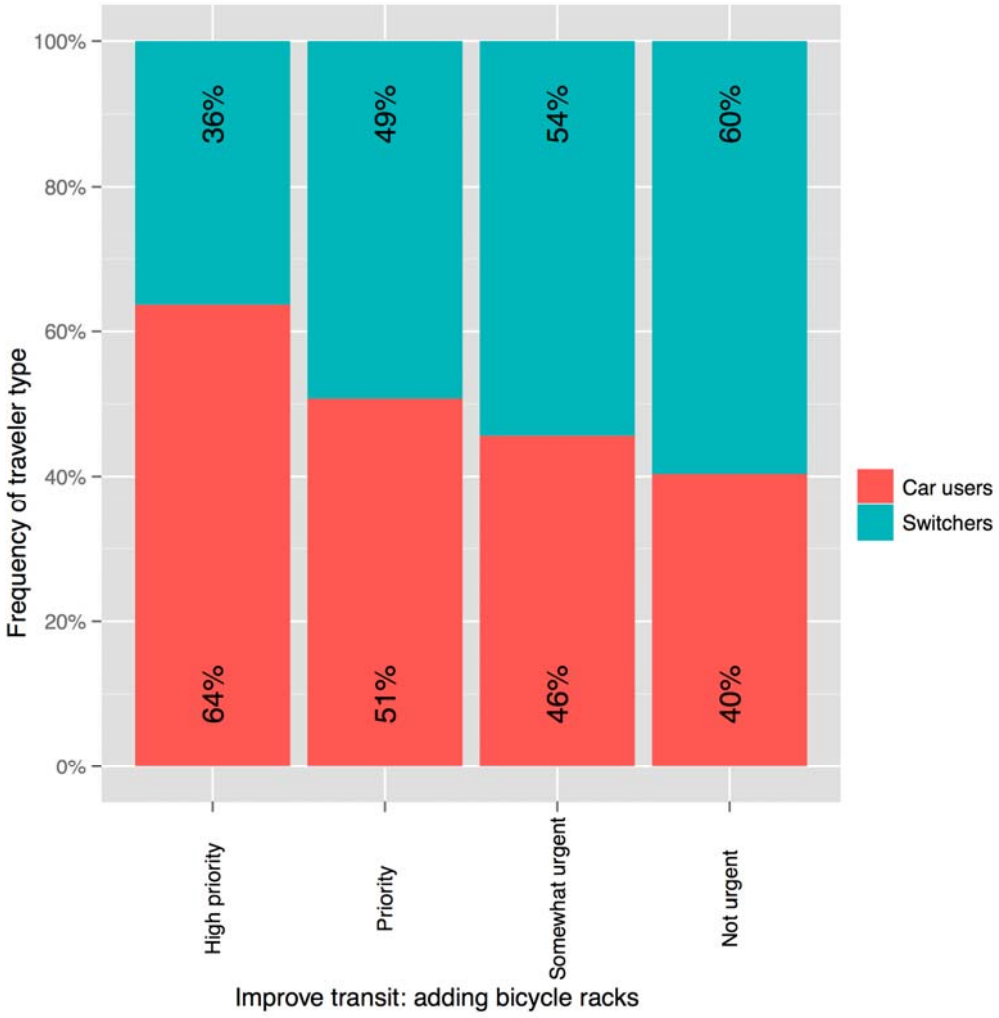
The same applies for the following question, as switchers claimed their support to increase parking rates in order to restrict car use on campus while non-switchers judge it is not urgent. Similar to the previous variable, the measure proposed here also holds potential to discourage students to come to university by car.

Figure 16 Descriptive chart of "GhWBT" variable



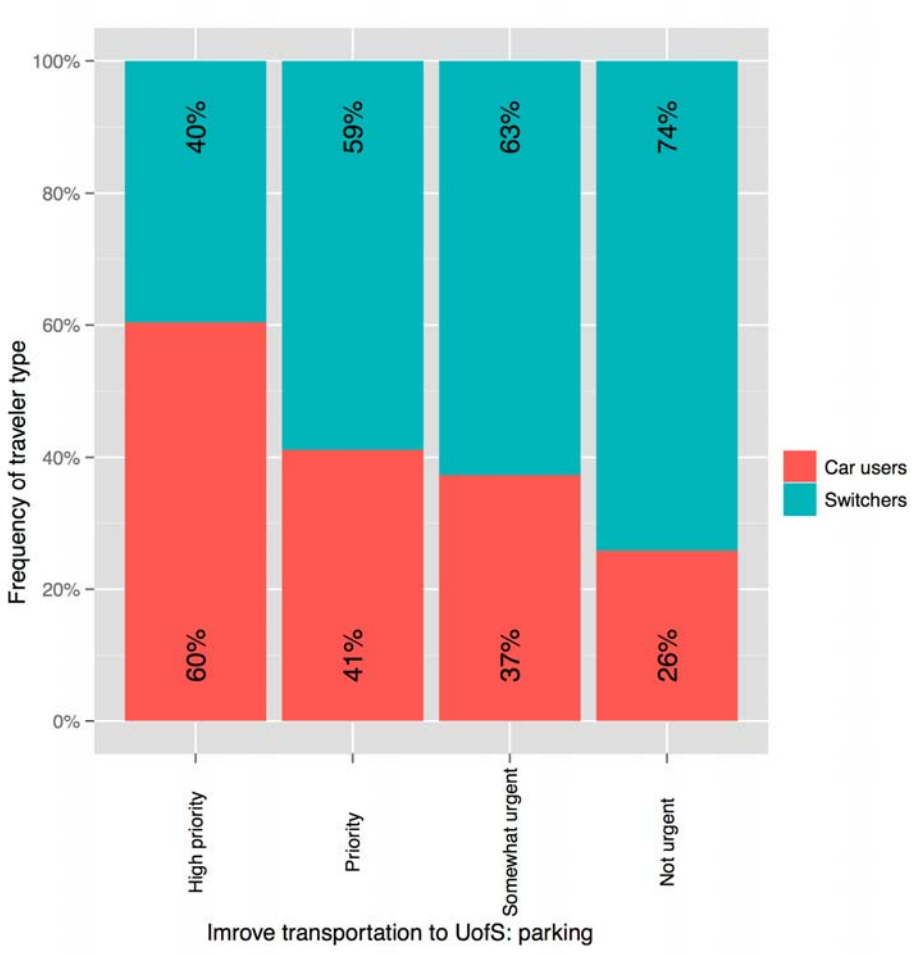
As a complement to this, the "GhWBT" variable shows the desire for switchers to prioritize walking, cycling, and transit as a way to reduce GHGs. Absolute numbers for this question show this measure has the advantage to be endorsed by both switchers and non-switchers. Respectively, 92 percent of switchers and 78 percent of non-switchers list it as a priority or high priority measure.

Figure 17 Descriptive chart of "ImpBc" variable



Remaining car users continue to use their cars often because the transit system does not fit their needs. In Figure 17, what non-switchers are telling us is they want a better integration between transit and active transport modes, such as prioritizing the addition of bicycle racks on buses as a way to achieve this intermodality.

Figure 18 Descriptive chart of "ImpUPK" variable



For the university, this figure demonstrates that parking was still an issue in 2005, one term after the U-Pass was implemented. Moreover, both switchers and non-switchers list parking as an issue to resolve with priority or high priority (respectively 63% and 81%). It is interesting to see that new transit users are willing to second a measure that would go against their principals expressed earlier by easing car use on campus.

In summary, switchers can be identified as:

- Wanting to restrict car use on campus (to reduce GHG);
- Wanting to increase parking rates (to restrict car use);
- Wanting to prioritize walking, cycling and transit (to reduce GHG);
- Against adding bicycle racks to buses (to improve transit);
- And against improving parking at UdeS.

Non-switchers can be identified as:

- Against restricting car use on campus (to reduce GHG);
- Against raising parking rates (to restrict car use);
- Wanting to prioritize walking, cycling and transit (to reduce GHG);
- Wanting to add bicycle racks to buses (to improve transit);
- And wanting to improve parking at UdeS.

5. RECOMMENDATIONS

We showed in this study that discounted bus passes can resolve transportation issues at universities, help transit agencies gain more ridership and subsidized service improvements meanwhile providing students with a cheap transportation option.

However, in order to trigger these positive effects, certain conditions must be respected. We put to front a few recommendations for universities who are looking at U-Pass programs to resolve their transportation issues or simply to offer more viable transportation options to

their students as part of a sustainability program. The following is a list of recommendations regarding the adoption of a U-Pass program.

Through the literature review, 3 elements emerged as being crucial to ensure the success of a discounted university pass program:

1. The U-Pass must offer a discount to students. The actual amount of the discount comes only second. As long as it offers a better value than the regular fare, students will respond positively.
2. Include the cost of the U-Pass in student tuition fees. Since the cost per ride factor is eliminated, students are not reminded of the cost of taking transit thus making the U-Pass more valuable.
3. The transit agency must react to the arrival of new users and adjust its service to keep the same quality level as before the U-Pass or even surpass that level.

The following is a list of possible complementary interventions:

- "Don't be afraid to use the power of the market. If there is excess demand for parking, consider raising the price" (Toor and Havlick, 2004) using a stiff ladder;

- Make sure the students buy into the idea and make it their own, after all this has to do with the environment and thus future generations;

- Some active transport users will inevitably transfer to transit. It is important to plan for actions that will encourage them to remain active transport users. The goal is to displace as much students as possible at the lowest cost and environmental impact. Concretely this means, more bicycle paths, more bicycle racks, and protected pedestrian walkways;

- Deploy an effective marketing strategy to make sure that students, present and prospective, are aware of the transportation options made available by the institution and their benefits. Few students choose an institution for their transportation options, but promoting the U-Pass may reach prospective students as it corresponds with their values;

- Improve service in all possible manners to turn students into lifelong transit captive users.

At the Université de Sherbrooke, the implementation of the pass has proven to be a success. After only 5 months of being in place, transit use grew by 31 percent and reached 57 percent modal share dethroning the car as the most popular transport mode to get to university. The RF analysis has allowed us to identify which students responded more favorably to the measure. These students have the following traits: they study in theology, ethics and philosophy, physical education or human sciences; they live relatively close to UdeS; do not have access to a car; chose their place of residence based on proximity to

transit or their study area; were passengers prior to the U-Pass; are in their first and second year of undergraduate studies; are 28 years of age and younger, and are part-time workers. In addition, having in hand the dominant traits of remaining potential switchers, i.e. students who mostly kept coming by car, the university can more efficiently focus its efforts on them. Indeed, UdeS can still hope to attract new users and improve its success. As we have seen, the program has attracted a maximum of students sensitive to a decrease in the cost of public transit. With 90 percent of the cost of the U-Pass subsidized by the university, reluctant students are preoccupied by external costs such as ease of use, comfort and time of travel. Officials at the university and at the agency must now concentrate on other influential factors to attract additional riders.

Keeping this in mind, we have produced a list of priority interventions based on the output of the RF model:

- Organize a promotional campaign aimed at reluctant faculties: medicine, health sciences and administration, but also towards students who are in their third and fourth year of undergraduate studies or are graduate, doctoral or postdoctoral students, and to those 29 years of age or older. It could explicitly show the added cost (payments, fuel, insurance, cost of parking and maintenance) of using a car for a 10 kilometer commute and compare possible savings if transit was used instead;

- Launch promotional events like the “week without my car” to encourage students to try other options. A marketing campaign that allows students to try out available

transportation options may lead to more permanent changes if the service is adequate (Toor and Havlick, 2004);

- For those who live relatively far from UdeS, the university should consider sending personalized public transit itineraries (using postal codes) through the internal e-mailing system;

Finally, The discounted transit fare allowed increasing the gap between the perceived cost of using a car and the actual cost of taking transit. For those who continue to use a car, this gap must be enlarged for them to start considering other options. Based on this, restrictions on student parking should not be overlooked even if instituting them can be controversial.

- Examples from other universities include: raising parking permit prices, introducing an adaptive parking fare increase based on distance traveled and/or not issuing parking permits to students who live relatively close to the campus, restricting access to campus to first-year and second-year students, or launch a system of variable permit costs based on the number of days a student parks on campus;

As for physical interventions,

- UdeS should prioritize walking, cycling and transit modes on its campus as both switchers and non-switchers support this measure;

- Since the university is located on a hill, answering non-switcher's wish to add bicycle racks to buses could prove to be effective;

- Last but not least, all possible service increases regarding public transit and active transport should be addressed, whether they be in the form of extended service hours, more buses, a dedicated shuttle service between campuses, more bicycle lanes or pedestrian paths.

5.1. Limitations

It is important to note that limitations of this study are inherent to the context in which the survey was conducted. Factors like land use, density, population, seasonality, location of the campus in regards to the city are all subject to change from one context to another. Thus affecting participation rates and profile of students adhering to a U-Pass program.

Another limitation comes from the sample itself. Although it is large, it has left out part time students who represent 51.5 percent of enrolled students for the 2004-2005 academic year while only 2 percent were surveyed. For this reason the results obtained in this study concern full time students only. Concerning recommendations put to front; since the data was collected in 2005, certain redundancies may show between what is proposed and what has already been applied in terms of transportation investments and service improvements at UdeS in recent years.

Finally, it is uncommon for universities to subsidize entirely a U-Pass program as it was the case for UdeS in 2004. Consequently, the results obtained from the launch of their U-Pass could be slightly more positive than non-subsidized or even partly subsidized programs.

6. CONCLUSION

In this work, it has been established that U-Pass brings undeniable benefits to all parties involved. With the methodology used, Random Forests classification method, we were able to identify switchers from non-switchers according to a number of criteria. We were also able to clearly identify the particular needs of each subgroup that has enticed or deterred them to switch. From my review of the literature, I believe that this methodology, commonly used in the field of biology and machine learning, is a powerful tool that could be applied to other studies in the field of urban transportation. Indeed, the RF model is highly successful at classifying users as switchers or non-switchers (classification success rate), offering strong predictive power of student travel habits. We can thus stipulate that similar surveys, or even thinned out surveys including only the most relevant questions highlighted here, combined to an analysis through RF may help predict the success rate of a U-Pass in different contexts. This information would be a valuable asset for the initial design phase of the program and for conceiving marketing strategies towards reluctant switchers. Also, a more accurate evaluation of demand will help transit authorities determine the applicable discount and possible service adjustments.

We also demonstrate that what could have been considered at first glance homogeneous populations of potential transit users, is in fact constituted of various sub-groups with specific needs that require distinct solutions. Amongst the student population of UdeS, it clearly appears that those students whose classes are scattered in different locations (those registered in medicine and health sciences faculties) find the use of transit inefficient for their needs. This is an organizational barrier that could be solved although may prove to be costly. On the other hand we have those students registered in business who apparently still believe that a car is an indispensable appendix to their personality. This can only be addressed through a change in culture. It will require appropriate leadership, positive reinforcement, time and probably some fairly stiff rates that will encourage them to leave their cars at home. Finally, for those who require a private car because they live outside the transit system's service area, this is a problem that should be treated by those considering the incident of urban sprawl, although, a satellite parking could provide the necessary incentive for some students.

From the results obtained, there is no doubt that the experiment at UdeS will be profitably extended to other categories (employee and faculty). Our case points to the fact that the threshold for which a discounted transit pass is beneficial is probably smaller than expected regarding the size of the community served, density of the population, centrality of its location and size of the transit network. This helps highlight the untapped potential of transferring such programs to a variety of contexts.

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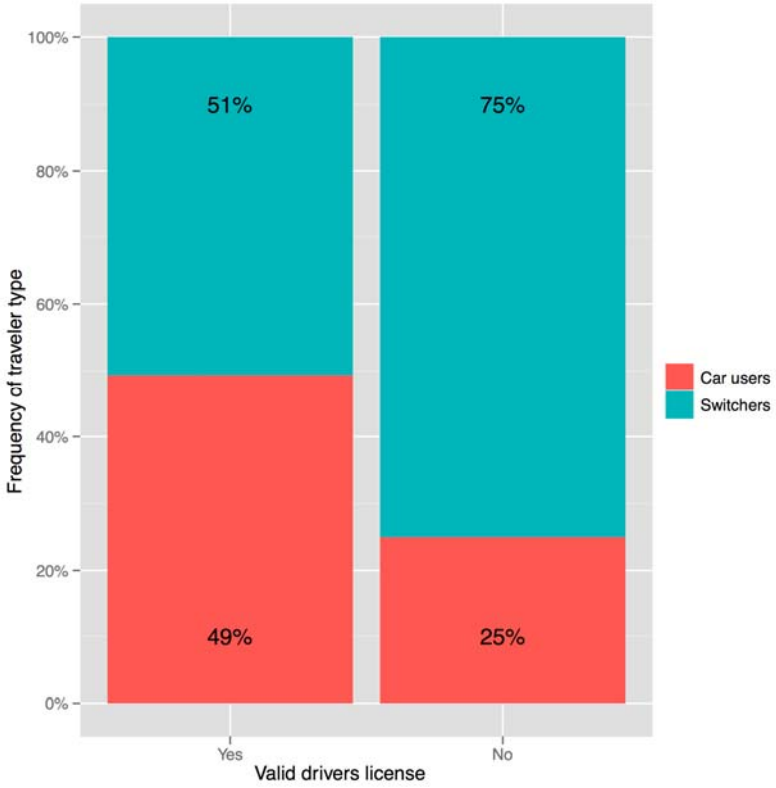
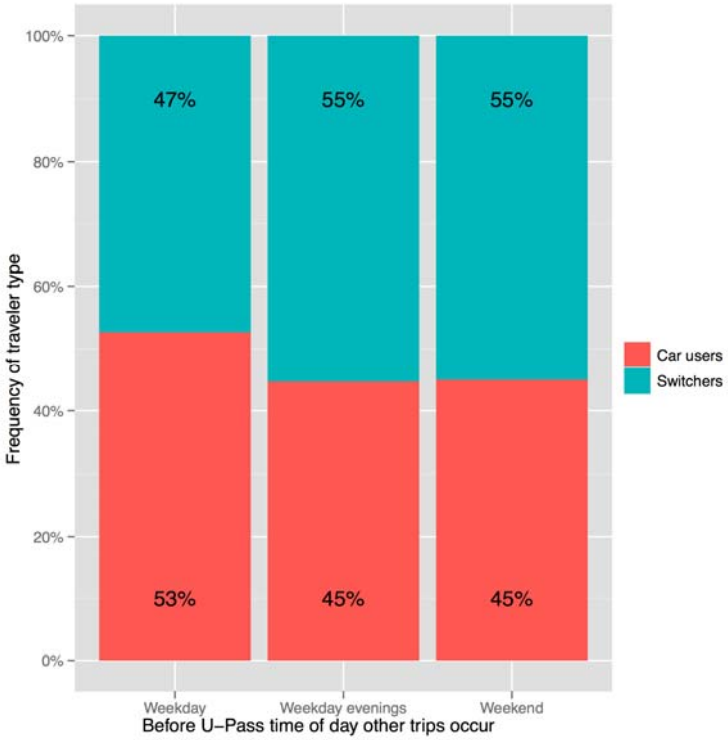
APPENDIX

Descriptive chart of "DrvLicen" variable



Descriptive chart of "BODay" variable



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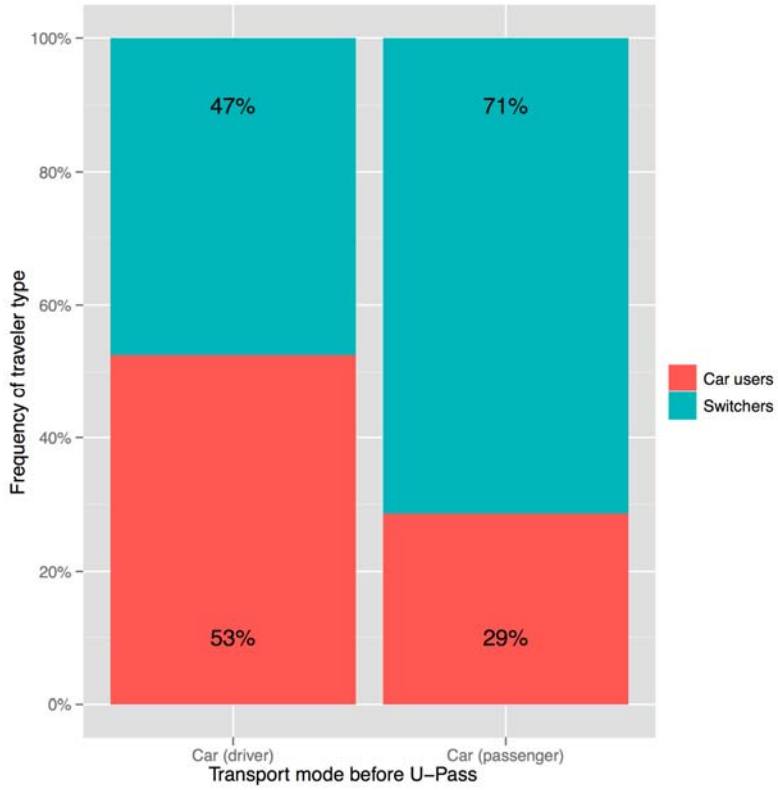

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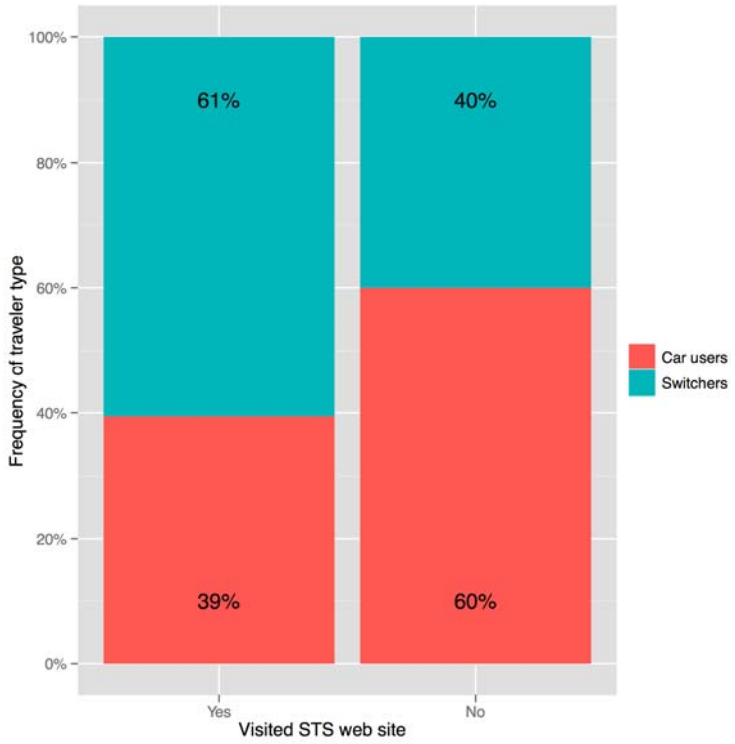

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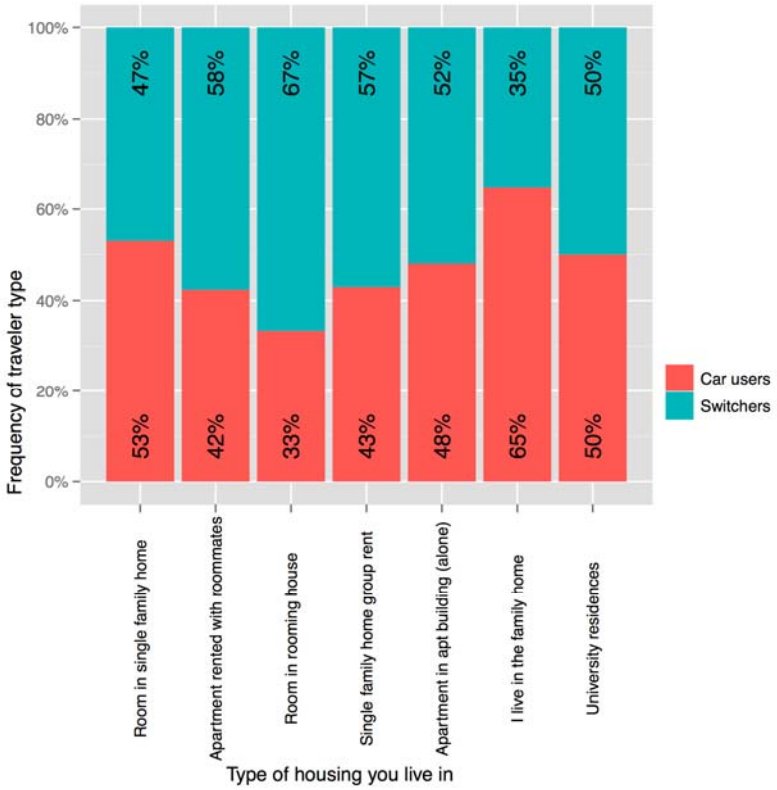

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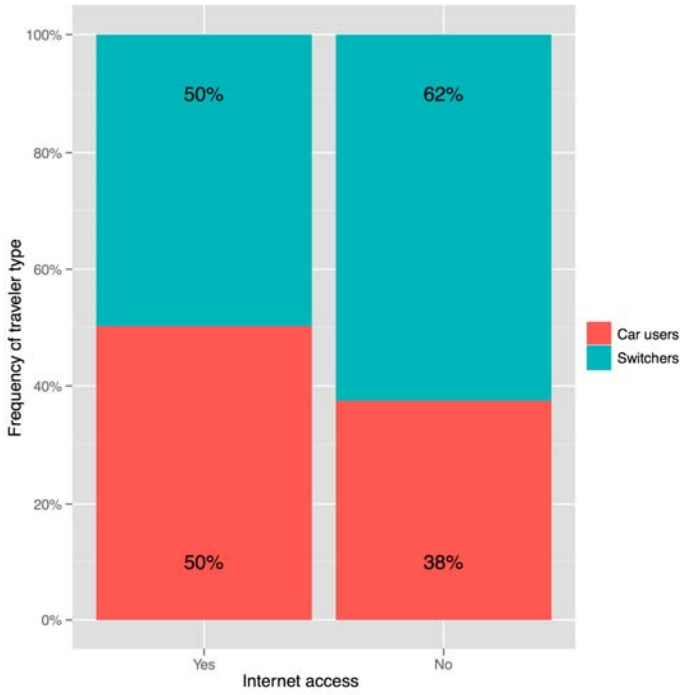

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