# RESEARCH ON PREDICTING DEMAND FOR INNOVATIVE INTERCITY TRAVEL MODES: A CASE STUDY OF TRAIN HÔTEL PROJECT

## Report: Stated Preference Survey Design

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# 1 INTRODUCTION

High speed trains have been operating in Europe and Asia for intercity transport. North America however, has yet to overcome the high cost of implementing and operating high speed trains. Realizing the importance of saving time in intercity travel, an alternative to traveling faster is to propose a method to make time pass in another way: *comfortably sleeping on a train!* This is where the overnight sleeper train with amenities and entertainment (TrH_On)[1], a Montreal-based train company stands that offers overnight round-trip rides between business and tourist capitals of Canada and U.S.: Montreal, New York City, Boston, Maine (Old Orchard, Ogunquit, etc.), etc. Moreover, for the Canadian side, the express train with amenities and entertainment (TrH_Exp) is proposed by this company to address the demand for intercity trips between major cities in Canada: Montreal, Sherbrooke, Bromont, etc.

In this project we will analyse the current travel demand between Montreal, Sherbrooke and Bromont as served local routes and between Montreal, New York City (NYC), Boston, Maine (Old Orchard, Ogunquit, etc.), etc. as international routes (also as national routes in the U.S.). Additionally, we will evaluate how an express train with amenities and entertainment (TrH_Exp) in Canadian side and overnight sleeper train with amenities and entertainment (TrH_On) for the rest of the routs can become a major alternative for intercity journeys.

Montréal is the largest city in the province of Quebec, and the second largest in Canada. The city has been established as an important centre of business, finance, industry, technology, arts and culture, and world affairs. It ranks as the largest economy of Quebec based on GDP and the second largest among Canadian cities, with a GDP of C$156 billion in 2014, placing it eighty sixth city in the world (The Bookings Institutions 2015). Montréal is also referred to as Canada's Cultural Capital (Wingrove 2008). The city is Canada's centre for French language television productions, as well as radio, theatre, film, music and art. Moreover, in 2009, Montréal was named North America's leading host city for international association events (Montréal News 2010). In 2015, Montréal was ranked the eighth best place in the world to be a university student (Quackuarelli Symonds 2015). The island of Montréal is a transportation hub for the province of Quebec. It is served by Quebec highways A-10, A-15, A-13, A-20, A-25, A-40, A-520, and A-720 many of which are frequently congested during rush hours. Also, VIA Rail provides rail service from Montréal to other cities in Canada, particularly to Quebec City and Toronto. Also from Montréal, the U.S. national passenger rail system, Amtrak, operates its Adirondack daily to New York City.

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1 From a business and individual daily travel point of view, providing an overnight sleeper train (TrH_On) with private rooms, working and dining areas, business rooms as well as showers etc. The TrH_On, arriving at its destinations, will have provided a leisurely and comfortable means of transportation for passengers.

Currently Montréal-New York and Montréal-Boston corridors generate a large amount of air and land traffic. This is due to the high level of activities related to commercial, service, and financial industries and the major cities of North America. Additionally, Maine; which based on the 2000 census Bureau and the 2010 census U.S is the thirty ninth most extensive and forty second most populous of the U.S states; has almost 400 km of coastline and 5600 km of tidal coastline. That said, along this states' rock-bound coast, there are several well-equipped beaches, islands, fishing villages, bays and inlets where over the year attract many tourist from all over the world to them especially from Canada.

On the proposed special overnight sleeper train between these business and tourist destinations, passengers will have the possibility of sleeping in a private bedroom with access to a lounge and a dining car, providing a leisurely and comfortable means of transportation that arrives at its destinations in the morning. On the other hand, the proposed especial express train between major cities in Canada such as Montreal Sherbrooke and Bromont which not only satisfy the intercity trips between these cities but also provides calm and comfortable environment for passengers especially for businessmen who need to relax or work during their commute. Moreover, in our research for the later new transportation mode, the proposed three track speeds (45 mph vs 60 mph vs 70 mph) will be studied and evaluated to choose the most optimized speed from passengers' and economic point of view.

In this project, we make use of the two approaches to design the data collection surveys for calculating the current and potential demand of the new transportation modes between our study area origin and destination points. These surveys target individuals who traveled from/to the study destination points either in Canada (express train with amenities and entertainment), between Canada and U.S. (overnight sleeper train with entertainment and amenities), or within U.S. (Trh_On) in the past two to twelve months for the day of the survey. Besides, to make the collected data representative of the population, people who did not travel to any of the study destinations in the 12 months but are interested to travel to these destinations are also considered in our study and a separate survey is designed specifically for them. That said, the demand for the new transportation modes will be estimated based on not only current travelers between theses destination points, but also potential travelers who did not get a chance to travel to these cities before or more frequently but interested to make a journey on the future. Hence, the estimated demand would be more accurate and reliable.

### 1.1 Traveling between Montréal and Sherbrooke

Another important city in Quebec is Sherbrooke, which is the sixth largest city in the province and thirteenth largest in Canada, is known as the primary economic, political, cultural and institutional centre of Quebec's Eastern Township. Sherbrooke, with inhabitants, is the fourth largest metropolitan area in Quebec and nineteenth largest in Canada (Census Canada 2015). Sherbrooke has the largest concentration of students in Quebec (Ville de Sherbrooke 2015). There are eight educational institutions with 40,000 students and 11,000 employees, 3,700 of

whom are professors, teachers and researchers (Université de Sherbrooke 2015).The Sherbrooke region is also attractive to tourists given that it is surrounded by mountains, rivers and lakes. There are several ski hills nearby and various tourist attractions in regional flavour. The Sherbrooke region is served by the Eastern Townships via highway A-10 and The Trans Quebec Highway A-55, accessed via the Jean-Lesage Highway A-20 which links Montréal and Quebec City.

Montréal and Sherbrooke have a distance of roughly 160 km between them. They are connected directly via highway A-10 providing easy driving access between the cities. There are several ways to travel between the two cities such as driving by car, airport shuttles, bus, carpooling, and cycling. Driving between the two cities takes roughly 1.5 hours without traffic.

Since most international flights land in Montréal's Pierre Elliott Trudeau International Airport, those traveling to Sherbrooke can be transported via a shuttle to their hotel in Sherbrooke or to Montréal's bus terminal where they can travel to several destinations in Sherbrooke including the city's bus terminal, downtown area, and university campus. Voyages Escapades 2000 manages a daily free shuttle service for its clients from Montréal's airport to their Sherbrooke destination hotel.

Another available travel mode includes Transdev Limocar bus service which provides transportation between Sherbrooke and Montréal, seven days a week. With a frequency between forty five minutes and two hours from Montréal to Sherbrooke and twenty five minutes to one and a half hours from Sherbrooke to Montréal. A one way ticket costs $41.25 with a travel times between two to two and half hours from Montréal to Sherbrooke and from two to three and a half hours from Sherbrooke to Montreal based on the type of ticket and the number of stops and connections. A roundtrip ticket costs $74.24 after tax. This mode of transportation is costly given the short distance between the cities and the uncomfortable nature of the busses that run between them while lengthy at the same time given that some trips have eighteen stops and take almost four hours.

Carpooling is also another available mode of transport between the two cities with a cost of $10 to $15, with two major websites providing access for drivers and passengers to connect (see (Amigo Express n.d.; Allo Stop n.d.). Cyclists can also travel between the two cities on the La Route verte bike path, traveling roughly 173 km.

### 1.2 Data Collection Survey Types

Data collection surveys for the purpose of studying safe and environmentally friendly transportation modes, are divided into three different techniques. The first survey is revealed preferences (RP) that makes use of travel behavior and a set of psychometric indicators to measure variables. The second survey is the stated preferences (SP) survey where the respondents are presented with hypothetical choices to evaluate and indicate their preferences

(Cavalcante 2013; Louviere et al. 2000; Atasoy & Bierlaire 2012). Due to their qualitative nature, perceptions are difficult to capture. In previous literature, a common way to collect information on a perception was to design a list of related survey statements and ask respondents to rate them based on total disagreement to total agreement (Likert 1932; Thorndike 1920). However, this approach has a significant limitation: the statements designed to capture an individuals' opinion is majorly reflected by the survey designer's conception of an attitude and not the respondents' representation of it (Glerum & Bierlaire 2012).

The various characteristics of the SP survey provides an ideal setting for modelling users' choices which include (Pearmain and Kroes, 1990):

- A guaranteed minimum accuracy level for the statistical models since the alternatives presented to respondents are controlled
- Minimum collinearity between variables since the survey is designed by the specialist
- The ability to quantitatively analyse new products and policies
- Smaller sample size compared to RP data since one respondent can generate more than one observation in the sample

On the other hand, the disadvantages of the SP methods are the lack of external validity, given the hypothetical scenario. These hypothetical scenarios provided to respondents do not reflect real behaviour in the model. For this reason, SP surveys are mostly used in conjoint analysis, functional measure, trade-off analysis, and transfer-price method (Pearmain and Kroes, 1990).

Another survey technique combines the two datasets RP and SP to exploit the variability of the SP data for the estimation of the RP model parameters (Atasoy & Bierlaire 2012). This method is ideal to analyze the respondent's choice among hypothetical choice alternatives and new multi-attributed alternatives. In other words, since the advantage of one method accounts for the shortcomings of the other method, the combination of the two methods provides data that when applied to a forecasting model, results in more accurate outcomes (e.g. SP – orthogonal statistical designs and RP – variables correlation).

In literature mixed RP-SP datasets have been used for the estimation of discrete choice models with several purposes. Ben-Akiva and Morikawa introduce the methodology to combine different datasets in order to utilize the advantages of one approach to overcome the limitations of the other (Ben-Akiva & Morikawa 1990; Atasoy & Bierlaire 2012). A combined RP-SP dataset is employed to estimate parameters and make use of the elasticity of the SP data. The combination is carried out by constraining a subset of the parameters of the two models to be the same and by introducing a scale parameter for the SP model. As a result, by combining RP and SP datasets, a price elastic demand model is obtained (Atasoy & Bierlaire 2012).

This report aims to establish a foundation for a data collection methodology to estimate the real and potential night time train demand between Montreal, Sherbrooke, Bromont, New York city (NYC), Maine (Old Orchard, Ogunquit, etc.), and Boston. Train Hôtel inc. is looking for extending its network to other cities by proposing new route. Amtrak and Via Rail are offering their collaboration to operate the overnight trains. Also, the governments of the five U.S. States that the trains are crossing are supporting the projects as well as the Municipal elected officials of both sides of the border. The Mayors of Montreal, Bromont, Magog, and other towns on the route, Tourisme Montreal, the Major International Events Group, the Quebec Tourism Industry Association and Evenko support the project. Moreover, several private investors are interested to finance the operation of the trains.

This research contributes to the development of data collection methods and modeling tools with focus on intercity train services. The aim of this research to help not only planners to integrate supply and demand in the long distance strategic decisions, but will also aid decision makers to propose more accurate strategies. By looking at the big picture, the proposed strategies based on our finding can be used to reduce the population automobile dependency based on the findings from the collected survey data.

## 2 CURRENT STUDY CONTEXT

In this project, we are looking into the possibility of using the existing or new railway infrastructure between Montreal, Sherbrooke, Bromont, New York City, Boston, Maine (Old Orchard, Ogunquit, etc.), etc. as new routes for the proposed new transit mode (TrH_Exp for Canadian side trips and TrH_On between Canada to U.S. or U.S. side trips) in order to improve not only the level of service of intercity transportation but also results in a positive impact on reducing GHG emission.

Between Montreal to Sherbrooke, New York city, Boston, and Maine (Old Orchard, Ogunquit, etc.) no reliable socio-demographic information is available in the disaggregated level to characterize intercity travelers. Hence, many fundamental inquiries such as users' travel behavior trends in the corridors, real and potential demands and their patterns over time, mode choice and model share in corridors, users' turnover rates changes, etc. remain unanswered.

In general, current daily travel modes between these cities can be categorised as car (private car), car rental, car-sharing (only for Canadian side), bus and heavy modes like plane and train. Some road users combined these travel modes for their intercity journeys such as bus and train, car and plane, etc. New data collection methods will help examine diverse aspects of current transit modes' improvement in order to increase interurban transport systems.

This research aims to design a mixed RP-SP survey with focus on intercity travelers between these three major cities. This is a first step towards a more comprehensive understanding of the mobility of people in interurban areas.

The specific objective of the paper is to design a RP-SP survey that would provide reliable long-distance journey data to:

- analyse the mode choice process results to evaluate the effects of:
    - socio-demographic attributes in modal preferences
    - attitudes and perception attributes
    - out-of-vehicle components: frequency and access/egress time
    - transit service components: reliability and onboard experience
    - etc.
- examine substitutional patterns between transit modes (modal shift or trading)
- quantifying cost sensitivity (with focus on different income groups and trip distances i.e. willingness to pay measure)
- study time sensitivity (value of time for each mode of travel)

Different discrete choice models can be used based on maximum likelihood techniques (multinomial, nested logit, etc.) to estimate the effects of different attributes on the above mentioned dependent variables based on the collected RP-SP data. That said, these models can measure the impact of different factors and attributes on the respondents' preferences (see Figure 1).

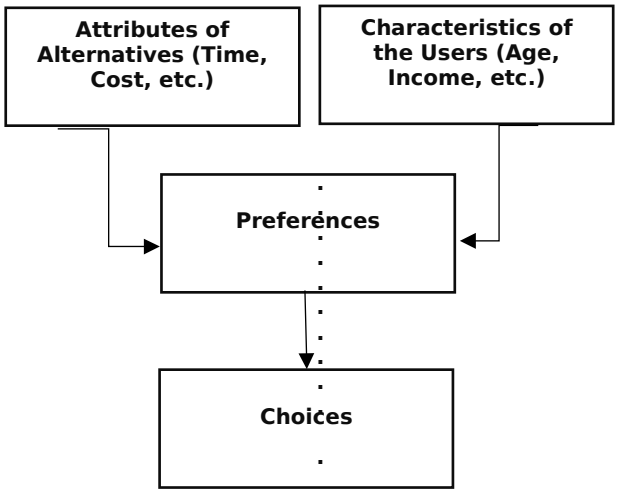



**FIGURE 1 Discrete Choice Frameworks** (Yang et al. 2013)

## 3 STATED AND REVEALED PREFERENCE SURVEY COMBINATION

There are two approaches that have been used to combine both sources of RP and SP data together (data enrichment) (Louviere et al. 2000). The first approach, proposed by Morikawa (1989), considers participants' answers to the SP survey with different scale for the random term of the utility function (calibration scale factors) (See (Morikawa 1989; Cavalcante 2013) for

more detail). In other words, respondents answer SP questions with more certainty (higher scale) or less certainty (lower scale) (see (Cavalcante 2013; Morikawa 1989)). Thus, both SP and RP estimates of trade-offs of attributes are assumed to be consistent.

The second method, developed by Swait et al. (1994), assumes the existence of unobserved attributes of alternatives which results in different answers to SP survey by respondents. This effect, has been presented by alternative specific constants. This method validates SP trade-offs and assumes that the RP data present existing market share information (Swait et al. 1994).

In this paper, we make use of the first approach to design our survey for the target group 1and 2 who either traveled in Canada or from Canada to U.S. Moreover, for people who either traveled from U.S. to Canada or inside U.S. (target group 3) the second method is employed. At the end, for target group 4 who did not travel to any of the study destinations in the 12 months but are interested to be traveled to these destinations Swait et al. (1994) method is adopted.

# 4 SURVEY DESIGN

The RP-SP exercises are based around a proposed railway network which connects Montreal-New York city via Bromont, and Montreal-Boston via Sherbrooke, etc. with a number of intermediate stops at major cities (e.g. between Montréal the major stops are St Jean, Farnham, Bromont, Lac Brome, and Magog). The survey should target travelers making journeys within this corridor so that it could be centred on an existing long-distance journey to strengthen the realism of the choices considered.

## *4.1* RP Part

The first step is to collect the socio-economic and intercity trip information of the respondents who travel between study are destinations (Montreal to Sherbrooke/Bromont/NYC/Boston/Main, etc.) such as individual characteristics (age, gender, occupation, education, driver license, etc.), household structure (number of children, teenagers and adults), income levels, car ownership, transit pass ownership, car-sharing membership[2] (e.g. Communauto, etc.), etc. The respondents are then asked to recall if they have made any trips between these destination cities in the past eight weeks (or past six to twelve months) and report the trips' information by providing us with their origins, destinations, start time, end time, transport modes, purposes for all these trips, frequency, etc. (Revealed Preference data).

Based on a set of sampling rules (see section 4.2.2.2), one trip would be chosen out of all the RP trips for each respondent and the respondents have to to provide more detailed information regarding that specific trip (number of baggage, who paid for the trip, accommodation cost, etc.). For example, if the major transit mode of the selected trip is car (private, rented or car-sharing), the respondent should mention journey time (including rest breaks and delay but not intermediate

2 Only for Canadian side

stops for other leisure activities), whether he used toll or not, etc. For bus and heavy transit modes, he should remember, access/egress time, number of transfers, ticket fee and whether used toll for access-egress if applicable based on access/egress modes, etc. (see Table 1 for more details)

**TABLE 1 Variables To be collected in the RP part of the Survey[3]**

| Individual level | Household level | Trip level | SP trip | | |
|---|---|---|---|---|---|
| | | | ***All modes*** | ***Car mode*** | ***Bus/train/plane mode*** |
| - age<br>- gender<br>- occupation<br>- education<br>- driver license<br>- transit pass ownership<br>- car-sharing [6] membership *(Commun auto, etc.)* | - number of children<br>- number of adults<br>- income level<br>- car ownership<br>- residential location *(postal code)*[4] | - origin *(city)*<br>- destination *(city)*<br>- start time<br>- start date<br>- end time<br>- end date<br>- transport mode<br>- purpose<br>- frequency<br>- one way or round trip<br>- number of nights away | - number of baggage<br>- who paid for the trip<br>- accommodation cost<br>- flexible schedule<br>- number of adults traveling with *(HH*[5] *member?)*<br>- number of children traveling with (HH member?) | - Cost *(excluding parking, toll fee)*<br>- journey time *(including rest break and delay but not stops for leisure activities)*<br>- parking fee<br>- owned or rented vehicle<br>- toll road used? | - scheduled departure time<br>- scheduled arrival time<br>- ticket cost<br>- access/egress mode: if car - parking fee, toll road used?<br>- transit company<br>- origin (postal code)<br>- destination (postal code) |

3 In the case of presence of no trips between origin and destination pair, only the "Individual" and "Household" level variables would be asked from participants and "Trip" level questions in both RP and SP part should be skipped as in the SP experiment section, participants in this category would be presented with a hypothetical trip

4 Household location would be only asked in the case of presence of no trips between the asked origin and destination pair

5 Household

6 Only for Canadian side (e.g. between Montreal to Sherbrooke/Bromont, etc.)

## 4.2 SP Part

There are five steps that should be followed in developing the SP survey: 1) defining key variables, 2) designing SP experimental design questions, 3) testing the initial survey with synthetic data, 4) revising the survey, and 5) implementing the web-based and supplemental surveys (see (Yang et al. 2013)).

In our survey, the intercity alternatives between study destination points are classified into three groups: 1) Participant's observed transit mode, 2) car-based mode (private car (C) and rental (Cr), car-sharing (Cs)[7]), and 3) public and heavy transportation modes (bus (Bs), airplane (Ar), regular train (Tr), express train with amenities and entertainments[8](TrH_Exp), and overnight sleeper train with amenities and entertainments (TrH_On)).

### 4.2.1 Attributes

Reviewing literature on transportation modes and intercity trips indicates that there are some factors that are important for road users regarding choosing their intercity transportation modes such as travel time, travel cost, transit service frequency, etc. (see (Burge et al. 2011; Yang et al. 2013) for more details). Additionally, there are some latent attributes (attitudinal factors) that might have significant effects on road users' preference.

As Louviere et al. (2000) discussed in his study, participants in most studies are presented with one to six choice sets where three to seven attributes have to be considered so that the scenarios would be more realistic and less complex (Pearmain & Swanson 1990; Louviere et al. 2000). Based on past studies, five key variables in the SP survey were carefully chosen to be coisderd in the SP survey experimental design. Moreover, 5 latent attributes at the end of the survey would be presenetd to partcipants to capture the effects of their perpection toward different tranist modes.

All in all, in our design, each transit mode alternative is characterized by the following variables (see Table 2.1 and 2.2 for each target group):

- ***Trip duration***: In this category, four travel time components are considered separately such as access and egress time, in-vehicle travel time (IVT) and waiting time at the station. These components are defined for each intercity transit mode based on their characteristics. For instance, access, egress and waiting time are not applicable for private car mode; while, the mentioned components' values are significantly different among public (bus) and heavy transportation modes. Also, it should be noted that for the TrH_Exp mode, since three speed track are proposed in the original project (45 mph vs. 60 mph vs 70 mph), three different IVT are presented for this transportation mode.

7 Only for Canadian side (e.g. between Montreal to Sherbrooke/Bromont, etc.)

8 Before proposing the scenarios in the next sections, at the beginning of the SP survey, we should briefly explain what the TrH_Exp or TrH_On is, how it works, and then propose the scenarios

- ***Journey time reliability***: This attribute is measured based on the percentage of trips that arrive within 10 minutes of the expected arrival time to be consistent with statistics collected by different transit mode operating companies specially.
- ***Heavy and public transit service frequency****: This variable is only applicable for Canadian side trip in TrH_Exp routes. Headway is used as the reliable measure for this attribute class in a sense that we would consider different time slots (6-9 AM, 9 AM to 12 PM, 12-3 PM, 3-6 PM, 6-12 PM and 12-6 AM) and the day of the trip (weekdays vs. weekends) as a factor to report the average headway for each transit mode in that time period of the day. These factors are relative to the departure time and date of the selected RP trip of the respondent.
- ***Start time****: This variable is only applicable for trip in TrH_On routes. For this variable three ~~tide~~ time slots are defined: morning (7 AM to 10 AM), day time (11 AM to 6 PM), and night time (7 PM to 6 AM).
- ***Travel cost***: Travel costs are presented for one-way journeys depending on the conditions for the selected trip. Moreover, separate costs are considered for the trips via TrH_Exp which represent different speed tracks. Additionally, the accommodation cost is also considered in the total trip cost. It should be noted that to present different cost between modes, in the hypothetical scenarios, the "travel cost" has to present along with the relative IVT (for trips in TrH_Exp routes) or "Start time" (for trips in TrH_On routes).
- ***Onboard experience***: onboard experience levels are described in a simple manner in Table 2. It should be noted the main focus of the onboard experience for the proposed night (TrH_On) or express train (TrH_Exp) should be on the chief cuisine (food variety and quality) and live music along with the quality of the space, service and comfort.

Each attribute should have at least two levels for non-linear utility function analysis. The values of these attribute levels should not only be reasonable, but also be related to participant's experience and allow the alternatives to compete with each other (Louviere et al. 2000; Pearmain & Swanson 1990). In our study, the service levels for the observed selected trip of the respondent are based on the participant's provided information. Additionally, the attributes' levels of service for each alternative mode are introduced based on Wilson (2008) and Burge et al. (2011) logic.

As illustrated in Table 2, each attribute varies across three levels (level 1 (L1), level 2 (L2) and level 3 (L3)). The values in this table are defined relative to origin and destination pairs that are imported average level of service information (secondary data) for each intercity transit mode (Wilson et al. 2008; Burge et al. 2011). In our research, this information should be gathered for each mode separately and added to the survey as secondary data to generate the accurate values for each origin-destination pair.

#### *4.2.1.1 Latent variables*

In our study, five qualitative variables (latent attributes): dependability, flexibility, environmental friendly, security and safety, are comfort are considered as potential attributes which might affect respondents' preference and choices (see (Outwater et al. 2003; Yang et al. 2013)). Hence, participants are asked to indicate their perception of these variable levels for each transit mode (see Question 7)

**TABLE 2. 1: SP Experiment Attribute Values and Their Levels of Service for Canadian Side Trips (Target Group 1, and 4)** *(e.g Montreal to/ from Sherbrooke, Bromont, etc.)*

| Attribute | | | Level | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Level 1 (L1)* | | | | | *Level 2 (L2)* | | | | | *Level 3 (L3)* | | | | |
| | | | ***C***[9] | ***Cr*** | ***Cs*** | ***Bs*** | ***TrH_Exp*** | ***C*** | ***Cr*** | ***Cs*** | ***Bs*** | ***TrH_Exp*** | ***C*** | ***Cr*** | ***Cs*** | ***Bs*** | ***TrH_Exp*** |
| ***Cost*** | *Transit*[10] *(Ct) ($)* | *General* | Ex[11] | Ex | Ex | Ex*0.8 | - | Ex*1.1 | Ex*1.3 | Ex *1.2 | Ex | - | Ex*1.4 | Ex*1.6 | Ex *1.5 | Ex*1.25 | - |
| | | *45 MPH* | - | - | - | - | Pr_45[12] | - | - | - | - | Pr_45*1.2 | - | - | - | - | Pr_45*1.4 |
| | | *60 MPH* | - | - | - | - | Pr_60 | - | - | - | - | Pr_60*1.2 | - | - | - | - | Pr_60*1.4 |
| | | *70 MPH* | - | - | - | - | Pr_70 | - | - | - | - | Pr_70*1.2 | - | - | - | - | Pr_70*1.4 |
| ***Travel time*** | *Access time (min): $T_1$* | | - | 15 | 5 | ~~Ex*0.75~~15 | ~~Pr*0.75~~15 | - | 20 | 10 | ~~Ex~~20 | ~~Pr~~20 | - | 25 | 15 | ~~Ex*1.25~~25 | ~~Pr*1.25~~25 |
| | *Waiting time (min): $T_2$* | | - | 10 | - | 15 | 5 | - | 15 | - | 20 | 10 | - | 20 | - | 25 | 15 |
| | *IVT*[13] *(hr) : $T_3$* | *General* | Ex*0.85 | Ex*0.85 | Ex*0.85 | Ex*0.75 | - | Ex | Ex | Ex | Ex | - | Ex*1.25 | Ex*1.25 | Ex*1.25 | Ex *1.25 | - |
| | | *45 MPH* | - | - | - | - | Pr_45 [14]*1 | - | - | - | - | Pr_45*1.15 | - | - | - | - | Pr_45*1.25 |
| | | *60 MPH* | - | - | - | - | Pr_60 [15]*1 | - | - | - | - | Pr_60*1.1 | - | - | - | - | Pr_60*1.2 |
| | | *70 MPH* | - | - | - | - | Pr_70 [16]*1 | - | - | - | - | Pr_70*1.05 | - | - | - | - | Pr_70*1.1 |
| | *Egress time*[17] *(min) : $T_4$* | | - | - | - | ~~Ex*0.75~~15±5 | ~~Pr*0.75~~15±5 | - | - | - | ~~Ex~~20±5 | ~~Pr~~20±5 | - | - | - | ~~Ex *1.25~~25±5 | ~~Pr*1.25~~25±5 |
| | ***Total*** *(hr)* | | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ |
| ***Reliability***[18] | | | 3 out of 20 times are delayed | 3 out of 20 times are delayed | 4 out of 20 times are delayed | 8 out of 20 services are delayed | 2 out of 20 services are delayed | 2 out of 20 times are delayed | 2 out of 20 times are delayed | 3 out of 20 times are delayed | 5 out of 20 services are delayed | 1 out of 20 services are delayed | 1 out of 20 times are delayed | 1 out of 20 times are delayed | 2 out of 20 times are delayed | 3 out of 20 services are delayed | It is rare that 1 out of 20 services are delayed |
| ***Service frequency*** | | | - | - | - | h(Ex) [19] | h(Pr) | - | - | - | Max (h(Ex)*1.5, 1) | Max (h(Pr)*1.5, 1) | - | - | - | Max (h(Ex)*2,2) | Max (h(Pr)*2,2) |
| ***Onboard experience*** | | | - | - | - | 2 out of 6 seats taken | Picture | - | - | - | 3 out of 6 seats taken | Picture | - | - | - | 4 out of 6 seats taken | Picture |

9 Intercity travel modes: Private car (C), Car rental (Cr), Car-sharing (Cs), bus (Bs), and express train with amenities and entertainment (TrH_Exp)

10 In the SP experiment scenarios, "price" and "IVT" and start time of each mode have to combined and presented together to the participant in case of presenting only cost as the important factor

11 Existing information based on OD pair and corridor form the secondary data sources should be updated

12 Predicted ticket fee for express train with amenities and entertainment (TrH_Exp) (45 mph (Pr_45) vs 60 mph (Pr_60) vs. 70 mph (Pr_70))

13 In-vehicle travel time (hr)

14 Predicted travel time based on 45 mph speed

15 Predicted travel time based on 60 mph speed

16 Predicted travel time based on 70 mph speed

17 If the selected RP trip (to be analyzed in the SP part) is claimed to be a round trip, the egress time for car-rental should be considered, otherwise it will be 0

18 Percentage of trips on-time (arrive within 10 mins of expected arrival time).

19 Average headway in each mode based on time slots and day of the week for the selected RP trip (see section 4.2.1)

**TABLE 2. 2: SP Experiment Attribute Values and Their Levels of Service for Trips from/to Canada to/from U.S. or inside U.S. (Target Group 2, 3, and 4)** *(e.g Montreal to NYC, Boston, Maine (Old Orchard, Ogunquit, etc.), etc.)*

| Attribute | | Level | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Level 1 (L1)* | | | | | | *Level 2 (L2)* | | | | | | *Level 3 (L3)* | | | | | |
| | | ***C***[20] | ***Cr*** | ***Bs*** | ***Ar*** | ***Tr*** | ***TrH_On*** | ***C*** | ***Cr*** | ***Bs*** | ***Ar*** | ***Tr*** | ***TrH_On*** | ***C*** | ***Cr*** | ***Bs*** | ***Ar*** | ***Tr*** | ***TrH_On*** |
| *Cost* | *Transit (Ct) ($)* | Ex[21] | Ex | Ex*0.8 | Ex*0.8 | Ex*0.8 | Pr[22] | Ex*1.1 | Ex*1.3 | Ex | Ex | Ex | Pr*1.2 | Ex*1.4 | Ex*1.6 | Ex*1.25 | Ex*1.25 | Ex*1.25 | Pr*1.4 |
| | *Accommodation (Ca) ($)* | Rep[23] | Rep | Rep | Rep | Rep | [24]Rep_1 | Rep | Rep | Rep | Rep | Rep | Rep_1 | Rep | Rep | Rep | Rep | Rep | Rep_1 |
| | ***Total*** *($)* | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca | Ct+ Ca |
| *Travel time* | *Access time (min) : $T_1$* | - | 15 | 15±5Ex*0.75 | 30±5Ex*0.75 | Ex*0.75 | 15±5Pr*0.75 | - | 20 | 20±5Ex | 40±5Ex | 20±5Ex | 20±5Pr | - | 25 | 25±5Ex*1.25 | 50±5Ex*1.25 | 25±5Ex*1.25 | 25±5Pr*1.25 |
| | *Waiting time : $T_2$* | - | 10min | 15 min | 1:30 hr | 20 min | 15 min | - | 15 min | 20 min | 2:15 hr | 25 min | 20 min | - | 20 min | 25 min | 3 hr | 35 min | 25 min |
| | *IVT[25] (hr) : $T_3$* | Ex*0.85 | Ex*0.85 | Ex*0.75 | Ex*0.7 | Ex*0.75 | Pr | Ex*1 | Ex | Ex | Ex*0.85 | Ex | Pr*1.1 | Ex*1.25 | Ex*1.25 | Ex*1.25 | Ex | Ex*1.25 | Pr*1.25 |
| | *Egress time(min) : $T_4$* | - | - | 15±5Ex*0.75 | 30±5Ex*0.75 | Ex*0.75 Ex*0.75 | 15±5Pr*0.75 | - | 20- | 20±5Ex | 40±5Ex | 20±5Ex | 20±5Pr | - | 25- | 25±5Ex*1.25 | 50±5Ex*1.25 | 25±5Ex*1.25 | 25±5Pr*1.3 |
| | ***Total*** *(hr)* | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ | $\Sigma T_i$ |
| ***Reliability***[26] | | 5 out of 20 times are delayed | 5 out of 20 times are delayed | 8 out of 20 services are delayed | 6 out of 20 services are delayed | 5 out of 20 services are delayed | 2 out of 20 services are delayed | 3 out of 20 times are delayed | 3 out of 20 times are delayed | 5 out of 20 services are delayed | 3 out of 20 services are delayed | 3 out of 20 services are delayed | 1 out of 20 services are delayed | 2 out of 20 times are delayed | 2 out of 20 times are delayed | 3 out of 20 services are delayed | 2 out of 20 services are delayed | 2 out of 20 services are delayed | It is rare that 1 out of 20 services are delayed |
| ***Start Time***[27] | | 7-10 AM | 7-10 AM | 7-10 AM | 7-10 AM | 7-10 AM | 7PM-6AM- | 11 AM-6 PM | 11 AM-6 PM | 11 AM-6 PM | 11 AM-6 PM | 11 AM-6 PM | 7PM-6AM- | 7PM-6AM | 7PM-6AM | 7PM-6AM | 7PM-6AM | 7PM-6AM | 7PM-6AM |
| ***Onboard experience*** | | - | - | 2 out of 6 seats taken | 3 out of 6 seats taken | 3 out of 6 seats taken | Picture | - | - | 3 out of 6 seats taken | 4 out of 6 seats taken | 4 out of 6 seats taken | Picture | - | - | 4 out of 6 seats taken | 5 out of 6 seats taken | Not reserved | Picture |

20 Intercity travel modes: Private car (C), Car rental (Cr), bus (Bs),plane (Ar), train (Tr), and overnight sleeper train with amenities and entertainment (TrH_On) ( For transit mode availability see Section 5.1)

21 Existing information based on OD pair and corridor form the secondary data sources should be updated

22 Predicted ticket fee for the overnight sleeper train with amenities and entertainment (TrH_On)

23 The accommodation cost would be the amount that the participant reported for the selected RP trip in the SP section (See Table 1)

24 Since the TrH_On operates during nights, the accommodation cost of the first night would be waived by the transit cost of this mode (i.e Rep_1=Rep-Rep/Number of nights away)

25 In-vehicle travel time (hr)

26 Percentage of trips on-time (arrive within 10 mins of expected arrival time).

27 In the SP experiment scenarios, “price” and “Start time” have to combined and presented together to the participant

### 4.2.2 Framing the Questions of the SP Survey

As mentioned in the Section 3, four target groups are considered in our study (Figure 2):

- ***Target group 1***: individuals who traveled inside Canada between Montreal, Bromont, Sherbrooke: Montreal, St- Jean, Farnham, Bromont, Magog, and Shebrooke
- ***Target group 2***: individuals who traveled from Canada to the U.S. (e.g. Montreal to Boston)
- ***Target group 3***: individuals who traveled from the U.S. to Canada or inside U.S. (e.g. from Boston to New York city)
- ***Target group 4***: individuals who did not travel between the studied destination points in the past 12 months but indicated their interest to travel in the future to the study destinations

For each of these groups, a different SP survey is designed: type 1, 2, and 3. More detail regarding these surveys is presented in Figure 3, 4, and 5 respectively.

In general, for all these target groups in the RP part of the survey, the socio-demographic characteristics of respondents such as age, gender, education level, transit pass ownership, etc., as well as their household information such as income levels, car ownership, etc. and finally their general long distance (LD) trips' detail information (in the past eight weeks (or six to eleven months) from the day of the survey) are collected such as, origin, final destination, mode of transportation, purpose of trips, accompaniment type, etc. Based on this information one of the trips will be randomly pooled out to be considered in the SP part.

The SP questions are organized in a logical sequence where respondents start with simpler questions and move to more complex questions later on. Also, the order of the alternatives is varied across respondents (although the order for each individual respondent remained the same) in order to control for potential ordering bias in the responses. That being said, the order of the attributes is not varied between respondents.

#### *4.2.2.1 Stated Preference Survey: Experimental Design*

In the SP experimental design of the survey four components have to be defined: 1) number of choice sets, 2) number of alternatives in each choice sets, 3) the variables which should be included in each choice set, and 4) level of service of attributes in each choice set (Cavalcante 2013).

Based on the information of the selected RP trip for target groups 1, 2 and 3 (origin, destination, travel time, and departure time), the transit mode choice hypothetical SP scenarios will be presented to each responded. For target group 4 where the respondents are interested to travel to the studied destination points in the future, a hypothetical trip based on the available routes will

be presented as a summary to them where they can choose their preferred transit mode presented by the various scenarios in the experimental design part of the survey.

One of the key challenge is to identify and organize the large choice set of transit modes and their related attributes (Yang et al. 2013). As mentioned before, six alternative intercity transportation modes are considered in our SP design along with users' observed transit mode for the selected journey: *private car, car rental, car-sharing*[28]*, bus service, plane, regular train and the proposed train service (TrH_Exp for travel within Canada or TrH_On for all other travels).* Participants are asked to select one preferred alternative in each scenario. It should be noted that the availability of transit modes depends on the participant's car ownership, driver license, trip origin and destinations, etc. (see section 5.1). In other words, participants will not be offered any alternatives that are not possible for their trip.

Since Pearmain and Kroes (1990) discussed the importance of defining restricted number of attributes in a SP survey, we chose five key variables among the top ranked attributes in the references which are also relevant to the objectives of this report (see (Burge et al. 2011; Pearmain & Swanson 1990; Yang et al. 2013; Cavalcante 2013)) (Table 2.1 and 2.2).

The procedure of combining different attributes with different level of service and proposing different choice sets and scenarios results in a set of different SP designs for each participant. For instance, Table 3 represents two selected variables by the participant combined with their level of service to define the SP scenario (three in this case). Based on this table, if the respondent chose only two attributes among the five attributes as his key variables; also if based on his origin and destination only three alternative transit modes are available (e.g. bus, train and plane), three scenarios can be presented to him in the SP experiment part along with his observed travel mode. Now, by referring to Table 3 we can combine the three levels of each attribute (*Level 1 (L1), Level 2 (L2) and Level 3 (L3*)) with regard to each alternative. It should be noted that, in addition to these transit alternatives, the current journey transit mode should also be presented to the respondent due to fact that each scenario has to be reasonable and realistic. That said, the respondent in each scenario can choose only one of the alternative modes for the chosen journey (see Question 6(Q6) in section 4.2.2.2).

**TABLE 3: Two Attributes: Three Choice Sets and Three Alternatives (Cavalcante 2013)**

| Scenario | Alternative 1 | | Alternative 2 | | Alternative 3 | |
|---|---|---|---|---|---|---|
| | *Variable 1* | *Variable 2* | *Variable 1* | *Variable 2* | *Variable 1* | *Variable 2* |
| 1 | L1[29] | L3[30] | L2 | L1 | L3 | L2 |
| 2 | L2[31] | L3 | L3 | L1 | L1 | L2 |
| 3 | L2 | L2 | L1 | L3 | L3 | L1 |

28 Only for Canadian side (e.g. between Montreal and Sherbrooke, etc.)

29 Level 1 value of the variable 1 based on Table 2 which should be updated for each origin-destination pair

30 Level 3 value of the variable 2 based on Table 2 which should be updated for each origin-destination pair

31 Level 2 value of the variable 1 based on Table 2 which should be updated for each origin-destination pair

#### *4.2.2.2 Basic Design of the Questionnaire*

The survey starts with questions regarding personal and household level information of the respondent and later an identifier question regarding existence of a trip in the past eight weeks (or six to eleven months) from the day of the survey between origin and destination pairs. Based on the target groups and number of samples we designed three surveys:

- ***RP-SP survey type 1***: is designed for target group 1 and 2 where the RP part of the survey obtains detailed tip information in the past 8 weeks (or 6 to 12 months). In the SP part of the survey, after participant classification and a random journey is selected, the SP experiment exercise is proposed based on Hensher and Greene's method (Hensher & Greene 2003). To avoid the non-attendance problem; which occurs when a variable is considered in a SP experiment but is not used by the participant in the preference choice process which results in its parameters' signification's reduction; the respondents are asked to rank each attribute level of importance from their perspective from a scale of 1 to 5 (1 as unimportant and 5 as very important) (Hensher & Greene 2003; Cavalcante 2013). At the end, the variables with rates more than and equal to 4 (important (4) or very important (5)) are considered to be included in the SP experiment design question (see (Cavalcante 2013)). If the number of selected attributes is less than two, the SP experiment has to be skipped and the scenarios with only one attribute should be presented for those participants. See Figure 3

- ***RP-SP survey type 2***: is designed for target group 3 where respondents report their three most recent or frequent journeys in the past 8 weeks (or 6 to 12 months). In the SP part of the survey, after participant classification and a random journey is selected, the method proposed by Swait et al. (1994) is adopted which considers only travel time, onboard experience, and the combination of cost along with start time. See Figure 4

- ***RP-SP survey type 3***: is designed for target group 4 where in the RP part, respondents are presented with a summary of a hypothetical trip while in the SP part, the same method is used as survey type 2. See Figure 5

Since our main focus of our research is on car users (private car, car rental or car-sharing), based on respondents' answers on the RP part of the survey, they will be grouped into four classes:

- ***Class 1***: Participants who in the past eight weeks (or six to eleven months) traveled between origin to destination with a transport mode other than a car

- ***Class 2***: Participants who in the past eight weeks (or six to eleven months) traveled between origin to destination only by car

- ***Class 3***: Participants who in the past eight weeks (or six to eleven months) traveled between origin to destination by car as a frequent transport mode

- ***Class 4***: Participants who in the past eight weeks (or six to eleven months) traveled between origin to destination by any mode other than car as a frequent transport mode

To start the SP section of the survey, participants in survey type 1 and 2, based on their class type, will be presented with the summary of one random journey based on their reported trips. For Class 2 and 3, the target journey for selection is among the trips that were made with car; while for Class 1 and 4, the randomly selected trip will be among the journeys where bus was not considered as their travel mode. In question 3 (Q3), respondents are required to provide more detailed information for their selected journey (see Table 1 for the type of variables obtained in this step).

Further, for survey type 1 and 2, participants in all the classes continue with question 4 (Q4) which indicates whether or not the participant considered cost as the only factor for choosing their transportation mode for the selected trip. If the answer is yes, question 5 (Q5) will be skipped and the SP experimental exercise (Q6) will be presented to the respondent by considering only cost as the effective attribute along with either IVT or start time for TrH_Exp and TrH_On respectively. If the answer to Q4 is no, the survey continues to Q5 for type 1, and to Q6 for type 2 by considering only the three mentioned variables (See Figure 3 vs. Figure 4).

Q5 is only available in the survey type 1, and it requires participants to indicate their level of importance for some key attributes in a five level Likert scale (1 being not important at all to 5 being very important). To proceed to the next questions, variables that are ranked as level 4 (important) or 5 (very important) are considered in the SP experiment design in Q6. This approach was implemented by Hensher and Greene (2003) to minimize non-attendance bias (Hensher & Greene 2003).

In Q6, respondents are asked to select transport alternatives for their selected journey given their service attributes in each SP experiment scenario. These attributes and their level of service which are included in this question are carefully selected from literature (see Table 2.1 and 2.2). The presented alternatives in each choice set is designed based on the available and feasible modes from seven choices: 1) current mode, 2) private car, 3) car rental, 4) car-sharing[32], 5) bus, 6) plane, 7) regular train, and 8) proposed train service (TrH_Exp or TrH_On) (For more detail of alternative mode availability see section 5.1).

In Q7, the latent attributes for all available intercity transport modes between the origin and destination for the chosen journey are presented and respondents are asked to rank them (1 to 5) based on their perception.

The final question (Q8) asks the respondent general questions and also whether they want to participate in a draw for an incentive.

32 This mode is only feasible and available for Canadian side (e.g. Montreal to Sherbrooke, etc.)

To better understand the questionnaire, a synthetic person in Class 2 is considered and the questionnaire is provided based on her answers. The synthetic person is a 32 years old woman who traveled from Montreal to New York City on Monday 7th of May 2016 at 6:30 PM via plane.

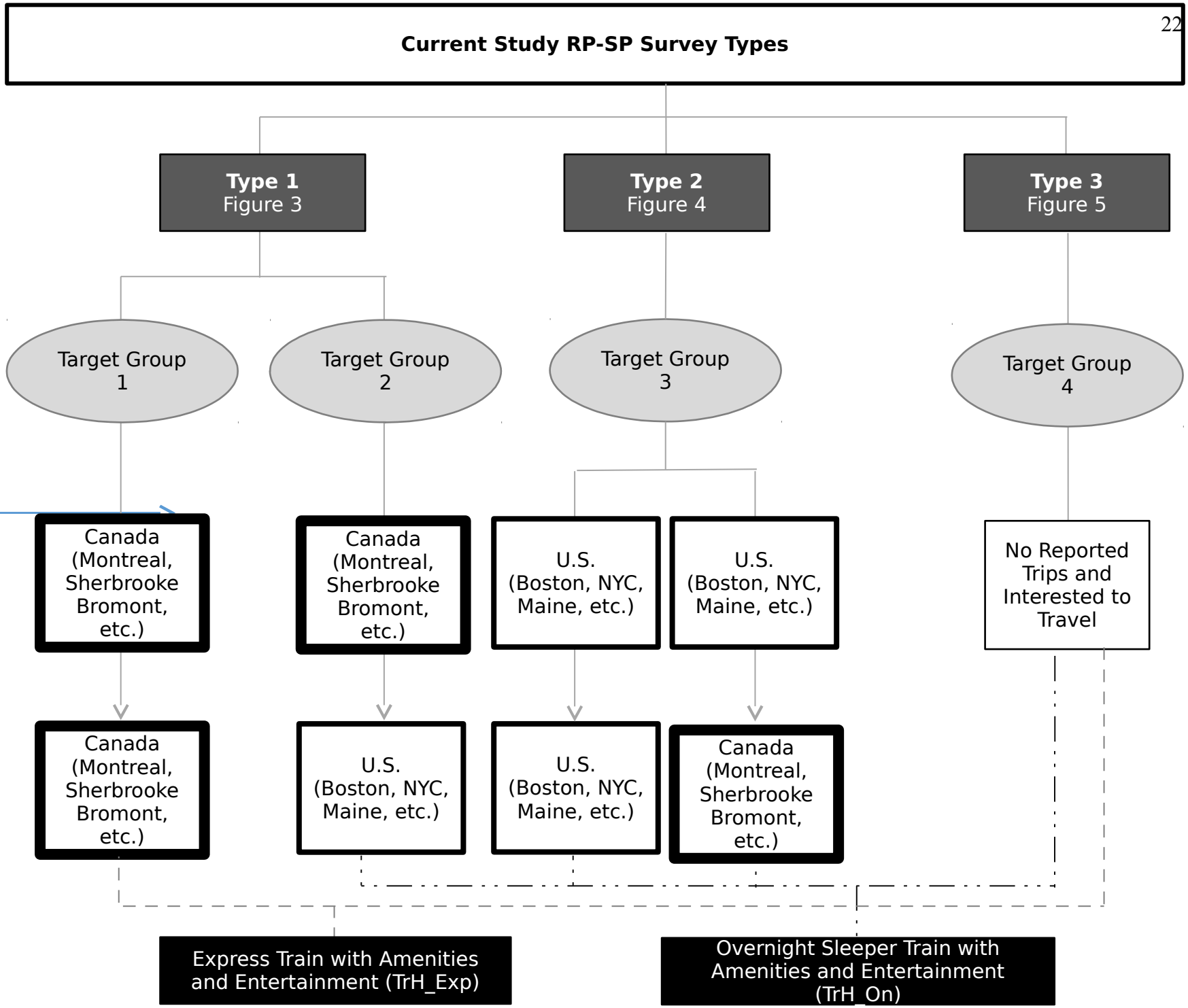



**FIGURE 1 Designed Survey Types According to Different Target Groups**

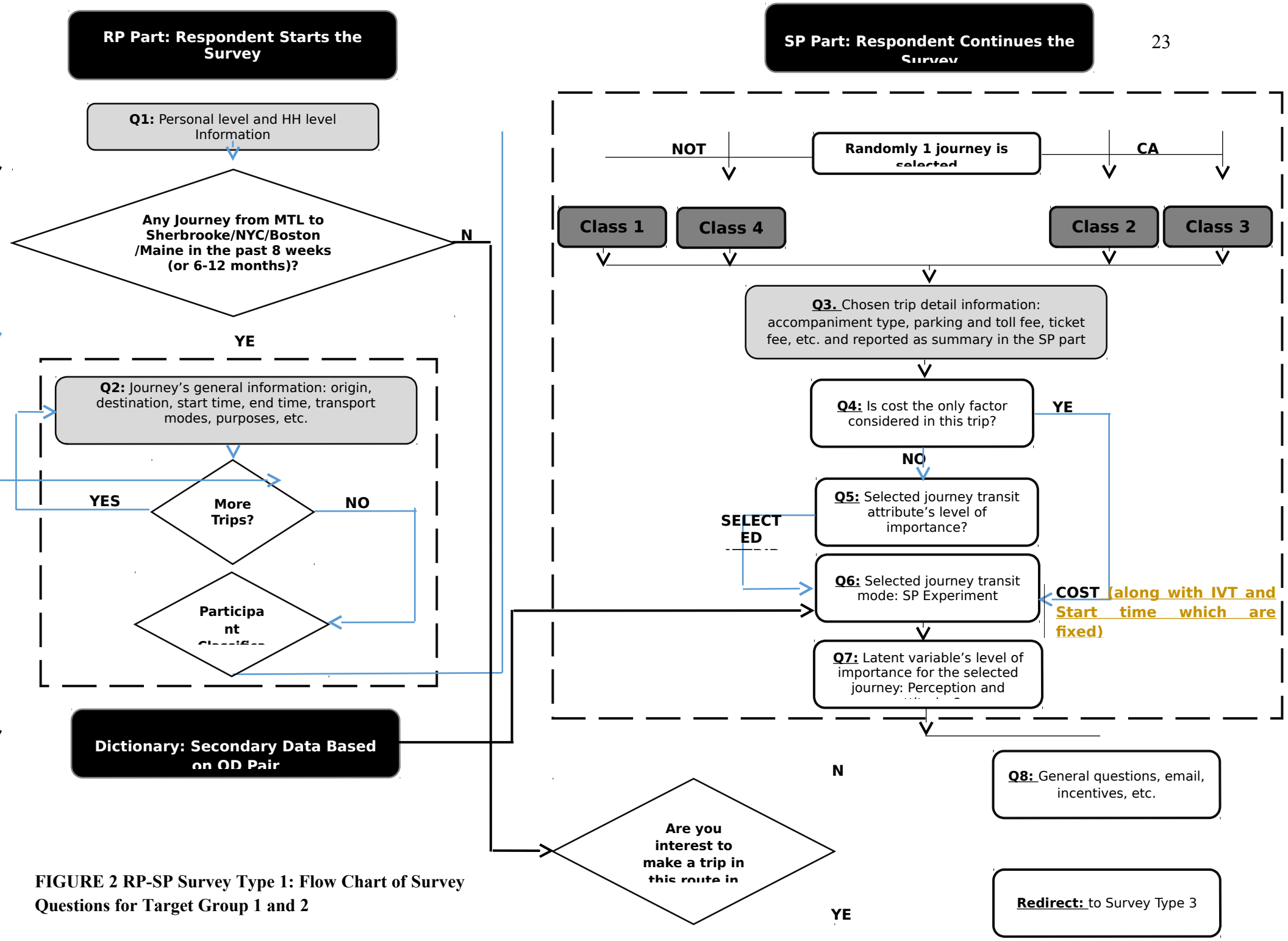



**FIGURE 2 RP-SP Survey Type 1: Flow Chart of Survey Questions for Target Group 1 and 2**

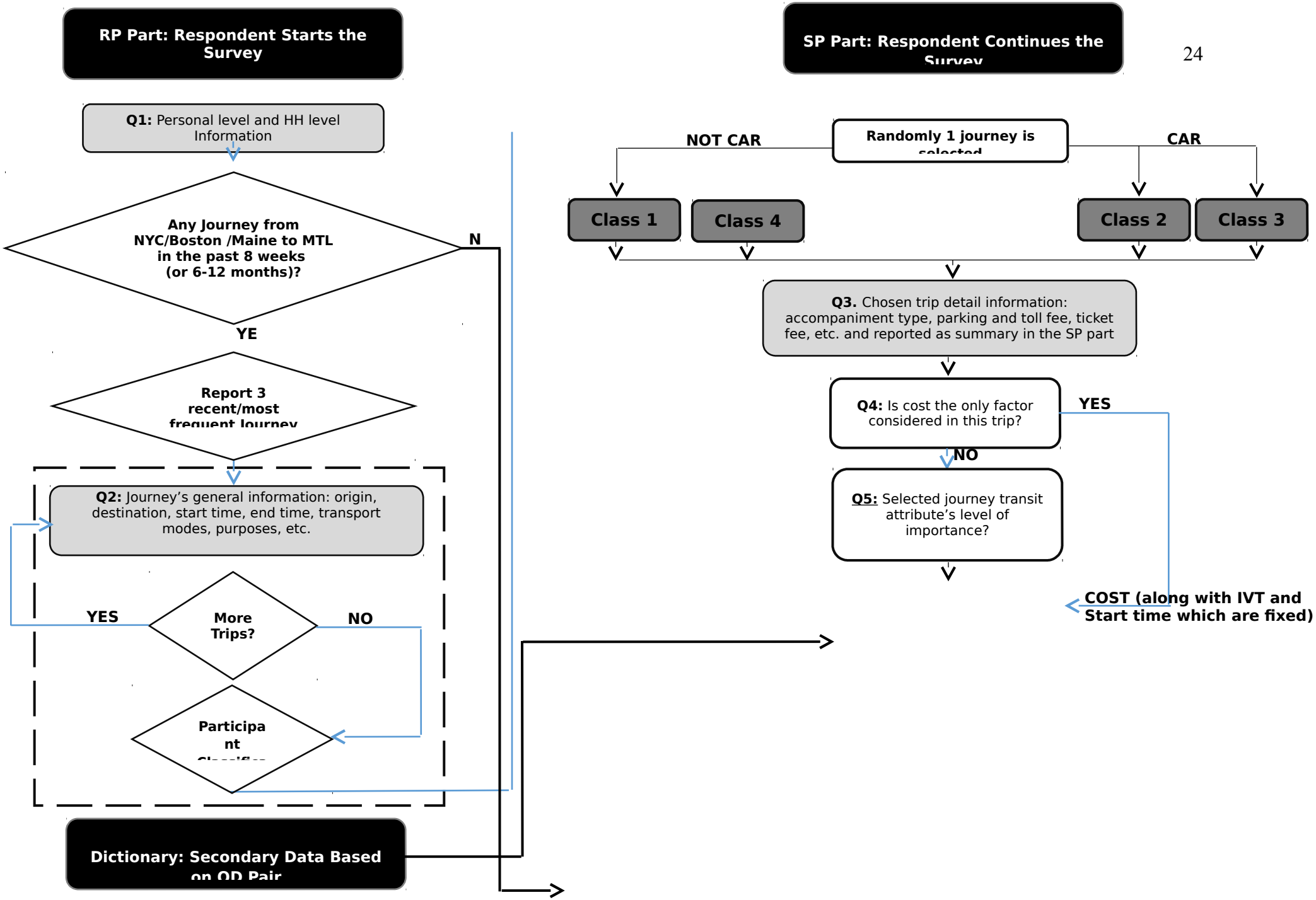
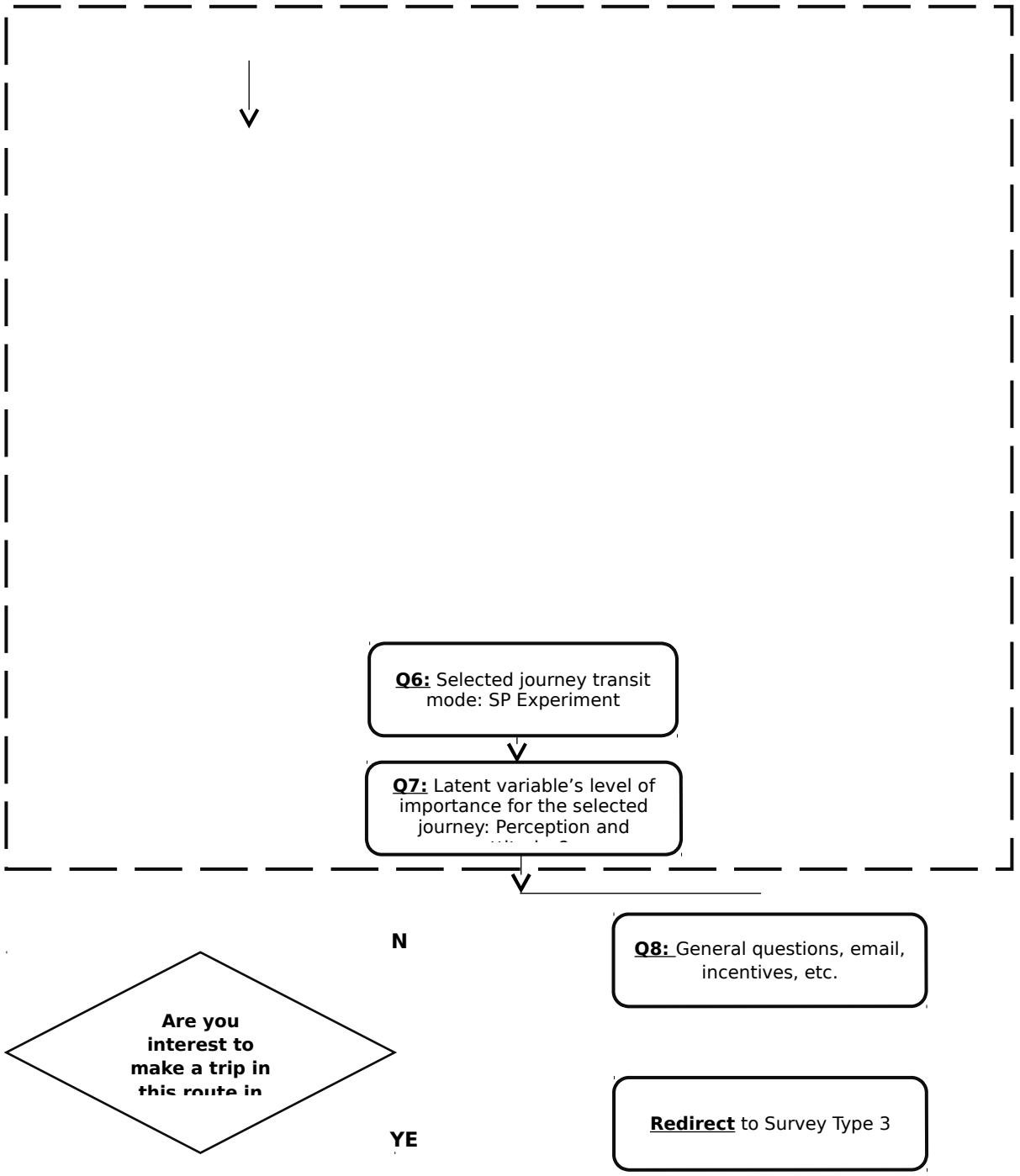



**FIGURE 4 RP-SP Survey Type 2: Flow Chart of Survey Questions for Target Group 3**


Q6: Selected journey transit mode: SP Experiment
Q7: Latent variable's level of importance for the selected journey: Perception and
N
Are you interest to make a trip in this route in
YE
Q8: General questions, email, incentives, etc.
Redirect to Survey Type 3

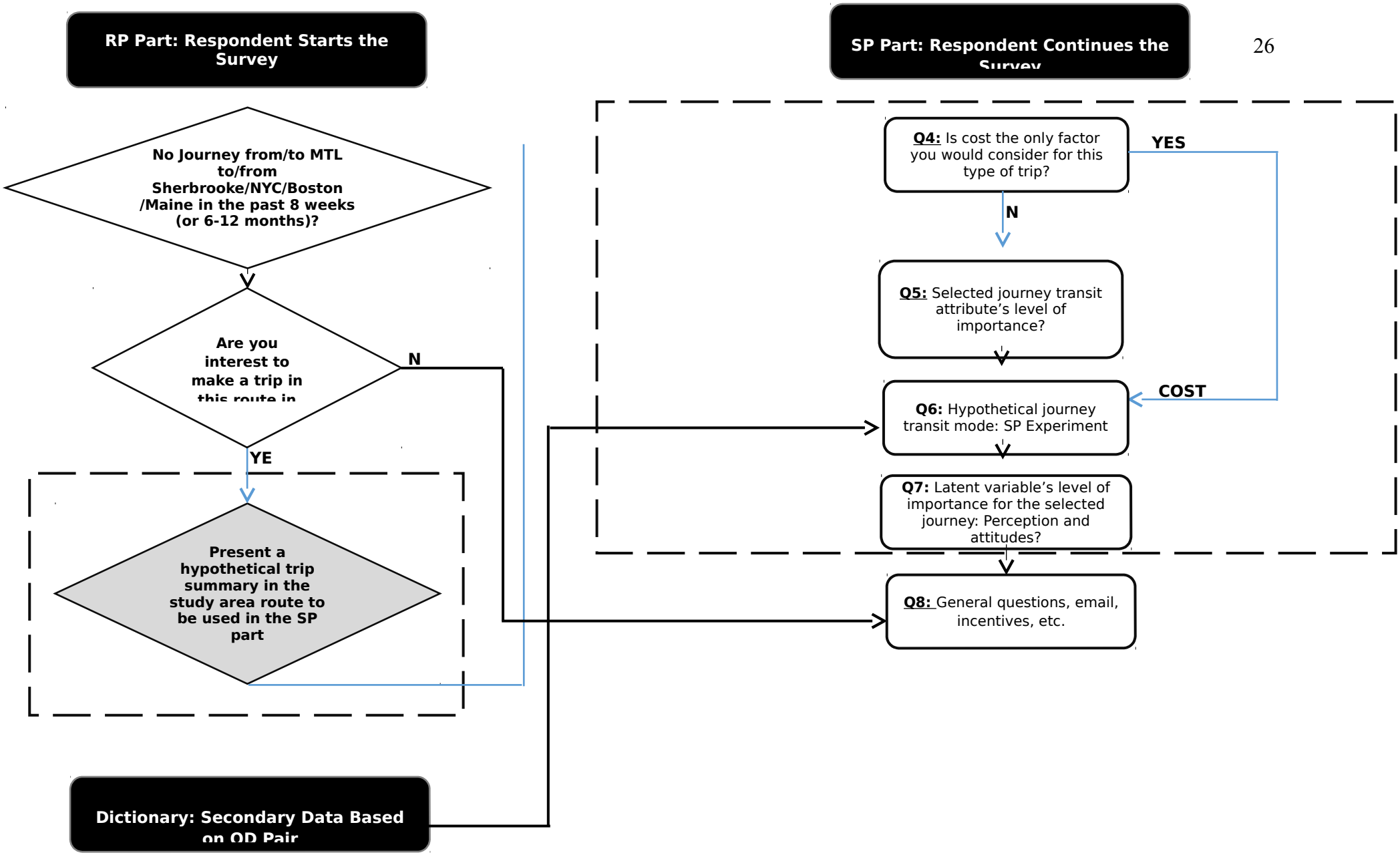



**FIGURE 5 RP-SP Survey Type 3: Flow Chart of Survey Questions for Target Group 4**

# 5 CHALLENGES & COMPLEXITY

There are numerous attributes that need to be considered for different transport mode alternatives with different level of services (see section 4.2.1).

In addition, transit alternatives are not uniform in format (e.g. waiting time is applicable to public and heavy transport modes only, etc.). Therefore, the organization and presentation of these alternatives and attributes are a challenge for the Stated Preference (SP) survey.

During the design, an additional challenge was to accommodate the availability of modes (not all modes are available for all origin destination pairs) and the base value of attributes for a certain mode (which are context dependent). Also, the success of the survey depends on how realistically the survey can be presented so that potential biases in the data are minimized.

## 5.1 Availability of Transport Modes

- Private car mode is only available for respondents who have a car in the household and also have a driving license
- Car rental will be available to adults that not only have driving license but also either used this mode for their long distance trip before or interested to use in future
- Car-sharing will be available only to adults who have driving license but also either used this mode for their long distance trip before or interested to use in future
- Overnight sleeper train with amenities and entertainment (TrH_On) is available for routes from Canada to the U.S. and routes within the U.S.
- Express train with amenities and entertainment (TrH_Exp) is available for routes within Canadian cities
- Heavy and public modes (train, plane, and bus) are only available for certain origin-destination pairs based on the secondary data. For instance, if the selected trip in the SP part is reported between Montreal and Sherbrooke, since there is no train and plane option to travel available between these two cities, these two options will not be presented to the respondent. However, there is a bus service in this corridor, so the bus service is a realistic and feasible for the respondent

## REFERENCES


Allo Stop, Carpooling in Quebec. *2015*. Available at: www.allostop.com.

Amigo Express, Carpooling long distance. *2015*. Available at: www.amigoexpress.com.

Atasoy, B. & Bierlaire, M., 2012. *An Air Itinerary Choice Model Based on a Mixed RP / SP Dataset*, Transport and Mobility Laboratory Ecole Polytechnique Federale de Lausanne.

Ben-Akiva, M. & Morikawa, T., 1990. Estimation of travel demand models from multiple data sources. *Transportation and Traffic Theory, New York: Elsevier*, pp.461–476.

Burge, P., Kim, C.W. & Rohr, C., 2011. *Modelling demand for long-distance travel in Great Britain*, RAND Corporation technical report. U.K. Department of Transport.

Cavalcante, R.A., 2013. *Freight market interactions simulation (FREMIS): An agent- based modeling framework*. Department of Civil Engineering, University of Toronto.

Census Canada, 2015. Census Profile – Sherbrooke Quebec (Census metropolitan area). *Census Canada*, 53(9), pp.1689–1699. Available at: http://www12.statcan.ca/census-recensement/2011/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CMA&Code1=433&Geo2=PR&Code2=24&Data=Count&SearchText=sherbrooke&SearchType=Begins&SearchPR=01&B1=All&Custom=&TABID=1 [Accessed November 24, 2015].

Glerum, A. & Bierlaire, M., 2012. The use of word data to measure perception in hybrid choice models. *International Conference on Travel Behaviour Research*, (July).

Hensher, D.A. & Greene, W.H., 2003. A Latent Class Model for Discrete Choice Analysis: Contrasts with Mixed Logit. *Transportation Research B*, 37(8), pp.681–696.

Likert, R., 1932. A Technique for the Measurement of Attitudes. *Archives of Psychology*, 22(140), pp.5–55.

Louviere, J., Hensher, D. & Swait, J., 2000. Stated Choice Methods: Analysis and Application. *Cambridge University Press*.

Montréal News, 2010. Montréal, top international convention host city in North America, Montréal 2025.

Morikawa, T., 1989. *Incorporating stated preference data in travel demand analysis*. Massachusetts Institute of Technology.

Outwater, M. et al., 2003. Attitudinal Market Segmentation Approach to Mode Choice and Ridership Forecasting: Structural Equation Modeling. *Transportation Research Record: Journal of the Transportation Research Board*, 1854, pp.32–42.

Pearmain, D. & Swanson, J., 1990. *Stated Preference Techniques. A guide to practice.* 1st ed. Steer Davies e Gleave Ltd., ed., London U.K.

Quackuarelli Symonds, 2015. QS Best Student Cities 2015. Available at: http://www.topuniversities.com/city-rankings/2015#sorting=rank+custom=rank+order=desc+search=. [Accessed November 24, 2015].

Swait, J., Louviere, J.J. & Williams, M., 1994. A sequential approach to exploiting the combined strengths of SP and RP data: Application to freight shipper choice. *Transportation*, 21(2), pp.135–152.

The Bookings Institutions, 2015. *2014 Global metro montreal map change in employment and GDP per capita (index of both rates)*, Available at: . http://www.brookings.edu/research/reports2/2015/01/22-global-metro-monitor.

Thorndike, E.L., 1920. A constant error in psychological ratings. *Journal of Applied Psychology*, 4(1), pp.25–29.

Université de Sherbrooke, 2015. Pôle Universitaire de Sherbrooke. Available at: http://pole.usherbrooke.ca/en/.

Ville de Sherbrooke, 2015. Proportion d'étudiants à Sherbrooke. Available at: http://www.ville.sherbrooke.qc.ca/citoyen/etudier-a-sherbrooke/.

Wilson, S., RAND Europe & Hugh Gunn Associates, 2008. Modelling Longer Distance Demand for Travel: Feasibility Study. *UK Department of Transport*.

Wingrove, J., 2008. Vancouver and Montréal among 25 most livable cities.

Yang, L. et al., 2013. Stated Preference Survey for New Smart Transport Modes and Services: Design, Pilot Study and New Revision. *Journal of Sustainable Tourism*, 21(4), pp.596–613.

# 6 APPENDIX I: RP-SP SURVEY SAMPLE (MONTREAL TO NEW YORK): RP-SP SURVEY TYPE 1 TARGET GROUP 2

## 6.1 RP Part

***Note1: Proposed questions in this section should address the variables mentioned in Table 1.***

***Note2: There should be several identifier questions before starting the RP part:***

1. In the past eight weeks (or past six to eleven months), have you traveled from Montreal to New York? (1. Yes, 2. No)
    - If no, ask if respondent is interested to take such a trip in the future?
        - If yes, redirect to survey type 3
        - If no, go to Q8
    - If yes, continue to RP section
2. Has anyone in your family already filled this survey? (1. Yes, 2. No, 3. Do not know)
3. [33]Have you used car-sharing for long distance trips? *(For 50% of the respondents (randomly)*

    o yes  o No

    - Conditional (If Yes): How often?
    - Conditional (If NO)[34]: Are you interested to consider this transit mode for your future intercity trips?

    o yes  o No
4. Conditional (if the responded has a driving license): Have you used car rental for long distance trips? (For 50% of the respondents (randomly)

    o yes  o No

    - Conditional (If Yes): How often?
    - Conditional (If NO): Are you interested to consider this transit mode for your future intercity trips?

    o yes  o No

33 Only for Canadian side (e.g. between Montreal to Sherbrooke, etc.)

34 If they answer to 4 is no, explain the "car-sharing" and then ask if they are interested or not?

**Answer to Q1**: The journey mode: only *plane* *Class 1*

**Answer Q2 and Q3**: Trip 3 is selected randomly: (*Montreal to New York)*

- *Female* - *32 Years Old*
- *Self-employed* - *Master's degree*
- *No driving license*
- *2 Adults in HH + 1 Children* - *Transit pass: Yes*
- *More than $75000* - *Start location: H2X 1C10*
- *1 car in HH* - *End location: 10011*
- *Trip origin: Montreal* - *Destination: New York city*
- *Start time/date: 4 AM (07/05/2016)* - *Scheduled departure: 6:30 AM*
- *Arrival time/date: 8:35 AM (07/05/2016)* - *Scheduled arrival: 8:00 AM*
- *Transport mode: Plane* - *Purpose: Business*
- *Access time: 40 min* - *Egress time: 35 min*
- *Access mode: Taxi* - *Egress mode: Taxi*
- *Frequency: Every 2 month* - *Round trip*
- *Stayed 3 nights* - *1 baggage*
- *She paid for the trip* - *Not flexible schedule*
- *Accompany: No one* - *Accommodation cost: $600*
- *Ticket fee (total): $282*
- *Porter airlines*
- *Does not have car-sharing membership and not interested in car-sharing*

### 6.2 SP Part

**Q4: For the selected trip (below), is cost the only factor you considered for selecting a transport mode?**

- If yes, go to Q6, and present the SP experiment scenarios based on cost and start time
- If no, proceed to Q5

**Q5: For the selected trip (below), how much did each of the following factors affect your journey mode choice? *(Scale 1-5) [Rand]***

*Trip 3: Montreal to New York*

- *Transport mode: Plane*
- *Access time: 40 min*
- *Departure 6:30 AM, 07/05/2016*
- *Arrival 8:35 AM, 07/05/2016*
- *Egress time: 35 min*
- *1 baggage*
- *Accompany: No one*
- *Accompany: #2 HH members*
- *Cost (one way): $141*
- *Frequency: Every 2 month*
- *Round trip*
- *Porter airlines*
- *Total one way cost (including accommodation): $741*

**1) Cost:**

1. Not important at all
2. Of little importance
3. Moderately important
4. Important
5. Very important

**2) Travel time:**

1. Not important at all
2. Of little importance
3. Moderately important
4. Important
5. Very important

**3) Onboard experience:**

1. Not important at all
2. Of little importance
3. Moderately important
4. Important
5. Very important

**4) Reliability (on time):**

1. Not important at all
2. Of little importance
3. Moderately important
4. Important
5. Very important

****** Note: Explain what the overnight sleeper train with amenities and entertainment (TrH_On) is and how it works and then propose the scenarios (video)***

**Q6: For the selected trip (below), if the following options among intercity transportation modes were available, which one would you choose? (*3 scenarios*)[35]**

*Trip 3: Montreal to New York*

- *Transport mode: Plane*
- *Access time: 40 min* - *Accompany: #2 HH members*
- *Departure 6:30 AM, 07/05/2016* - *Cost (one way): $141*
- *Arrival 8:35 AM, 07/05/2016* - *Frequency: Every 2 month*
- *Egress time: 35 min* - *Round trip*
- *1 baggage* - *Porter airlines*
- *Accompany: No one* - *Total one way cost (including accommodation): $741*

***Scenario 1:***

[36]

| | | Current mode | Bus | Plane | Train | TrH_On |
|---|---|---|---|---|---|---|
| **Cost** *($)* | Ct[37] | 141 | 123.75 | 133.6 | 137.5 | 240 |
| | Ca[38] | 600 | 600 | 600 | 600 | 400 |
| | Total | 741 | 723.75 | 733.6 | 737.5 | 640 |
| **Reliability** | | 5 out of 20 arrivals are delayed | 8 out of 20 arrivals are delayed | 3 out of 20 arrivals are delayed | 3 out of 20 arrivals are delayed | It is rare 1 out of 20 arrivals are delayed |
| **Preferred Alternative** | | | | | | x |

***Scenario 2:***

| | | Current mode | Bus | Plane | Train | TrH_On |
|---|---|---|---|---|---|---|
| **Cost** *($)* | Ct | 141 | 79.2 | 167 | 137.5 | 240 |
| | Ca | 600 | 600 | 600 | 600 | 400 |
| | Total | 741 | 679.2 | 767 | 737.5 | 640 |
| **Reliability** | | 5 out of 20 arrivals are delayed | 5 out of 20 arrivals are delayed | 6 out of 20 arrivals are delayed | 2 out of 20 arrivals are delayed | It is rare 1 out of 20 arrivals are delayed |
| **Preferred Alternative** | | | | | | x |

35 Since the respondent does not have a driving license (in RP part), the "car and rental" alternatives will not be presented to her. Also, as she does not have rideshare membership and not interested in this mode, the "car-sharing" alternative is not applicable to her.

36 Based on the selected origin, destination, etc., the attributes' levels of service for each alternative mode are provided in Table 4 in Appendix 2.

37 Transit cost

38 Accommodation cost

***Scenario 3:***

| | | Current mode | Bus | Plane | Train | TrH_On |
|---|---|---|---|---|---|---|
| **Cost** *($)* | Ct | 141 | 123.75 | 133.6 | 110 | 280 |
| | Ca | 600 | 600 | 600 | 600 | 400 |
| | Total | 741 | 723.75 | 733.6 | 710 | 680 |
| **Reliability** | | 5 out of 20 arrivals are delayed | 5 out of 20 arrivals are delayed | 2 out of 20 arrivals are delayed | 5 out of 20 arrivals are delayed | It is rare 1 out of 20 arrivals are delayed |
| **Preferred Alternative** | | | | | | x |

**Q7: Considering your selected journey, rank the level of ~~agreement regarding each statement~~each below attributes ~~based on~~for each transport mode based on your experience or perception[39]:**

*Trip 3: Montreal to New York*

- *Transport mode: Plane*
- *Access time: 40 min*
- *Departure 6:30 AM, 07/05/2016*
- *Arrival 8:35 AM, 07/05/2016*
- *Egress time: 35 min*
- *1 baggage*
- *Accompany: No one*
- *Accompany: #2 HH members*
- *Cost (one way): $141*
- *Frequency: Every 2 month*
- *Round trip*
- *Porter airlines*
- *Total one way cost (including accommodation): $741*

- **7.1: based on your experience or perception rank the "dependability" of intercity BUS ~~(dependability)~~for the above trip**

1. Not at all
2. Of little
3. Moderately dependable
4. Dependable
5. Very dependable

- ~~Completely disagree~~ ~~o Agree~~
- ~~Disagree~~ ~~o Completely agree~~
- ~~Moderately~~ ~~agree~~ ~~o I do not know~~

- **7.2: based on your experience or perception rank the "dependability" of intercity TRAIN for the above trip ~~I can count on the ------TRAIN-------- to get me to my destination on time (dependability)~~**

1. Not at all
2. Of little
3. Moderately dependable
4. Dependable
5. Very dependable

- ~~Completely disagree~~ ~~o Agree~~
- ~~Disagree~~ ~~o Completely agree~~
- ~~Moderately agree~~ ~~o I do not know~~

- **7.3: based on your experience or perception rank the "dependability" of intercity PLANE for the above trip~~I can count on the ------PLANE-------- to get me to my destination on time (dependability)~~**

1. Not at all

39 Since the respondent does not have a driving license (in RP part), the statement regarding "car" alternative will not be presented to her.

2. Of little
3. Moderately dependable
4. Dependable
5. Very dependable

- ~~Completely disagree o Agree~~
- ~~Disagree o Completely agree~~
- ~~Moderately agree o I do not know~~

- **7.4: The ------BUS-------- offers me the flexibility I need for my schedule (flexibility)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know
- **7.5: The ------ TRAIN -------- offers me the flexibility I need for my schedule (flexibility)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know
- **7.6: The ------ PLANE -------- offers me the flexibility I need for my schedule (flexibility)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know
- **7.7: Using ------ BUS -------- is environmentally friendly (environment)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know
- **6.8: Using ------ TRAIN -------- is environmentally friendly (environment)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know
- **7.9: Using ------ PLANE -------- is environmentally friendly (environment)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know
- **7.10: ------ BUS -------- is not secure (security)**

- Completely disagree o Agree
- Disagree o Completely agree
- Moderately agree o I do not know

- **7.11: ------ TRAIN -------- is not secure (security)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know

- **7.12: ------ PLANE -------- is not secure (security)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know

- **7.13: ------ BUS -------- is very crowded (comfort)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know

- **7.14: ------ TRAIN -------- is very crowded (comfort)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know

- **7.15: ------ PLANE -------- is very crowded (comfort)**
  - Completely disagree o Agree
  - Disagree o Completely agree
  - Moderately agree o I do not know

# 7 APPENDIX II

**TABLE 4 Revealed Preference Variable Levels for the Synthetic Peron in Appendix I**

| Attribute | | Level | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Level 1 (L1)* | | | | | | *Level 2 (L2)* | | | | | | *Level 3 (L3)* | | | | | |
| | | ***C*** | ***Cr*** | ***Bs*** | ***Ar*** | ***Tr*** | ***TrH_On*** | ***C*** | ***Cr*** | ***Bs*** | ***Ar*** | ***Tr*** | ***TrH_On*** | ***C*** | ***Cr*** | ***Bs*** | ***Ar*** | ***Tr*** | ***TrH_On*** |
| ***Cost*** | *Transit (Ct) ($)* | 70 | 100 | 79.2 | 133.6 | 88 | 200 | 77 | 130 | 99 | 167 | 110 | 240 | 98 | 160 | 123.75 | 208.75 | 137.5 | 280 |
| | *Accommodation (Ca) ($)* | 600 | 600 | 600 | 600 | 600 | 400 | 600 | 600 | 600 | 600 | 600 | 400 | 600 | 600 | 600 | 600 | 600 | 400 |
| | ***Total*** *($)* | 670 | 700 | 679.2 | 733.6 | 688 | 600 | 677 | 730 | 699 | 767 | 710 | 640 | 698 | 760 | 723.75 | 808.75 | 737.5 | 680 |
| ***Travel time*** | *Access time (min) : $T_1$* | - | 15 | 11 | 30 | 15 | 15 | - | 20 | 15 | 40 | 20 | 20 | - | 25 | 19 | 50 | 25 | 25 |
| | *Waiting time : $T_2$* | - | 10min | 15 min | 1:30 hr | 20 min | 15 min | - | 15 min | 20 min | 2:15 hr | 25 min | 20 min | - | 20 min | 25 min | 3 hr | 35 min | 25 min |
| | *IVT (hr) : $T_3$* | 5.1 | 5.1 | 6.4 | 1.1 | 8.3 | 11 | 6 | 6 | 8.5 | 1.275 | 11 | 12.1 | 7.5 | 7.5 | 10.625 | 1.5 | 13.75 | 13.75 |
| | *Egress time(min) : $T_4$* | - | - | 15 | 34 | 15 | 15 | - | - | 20 | 45 | 20 | 20 | - | - | 25 | 56 | 25 | 26 |
| | ***Total*** *(hr)* | 5.1 | 5.5 | 7.1 | 3.6 | 9.1 | 11.8 | 6.0 | 6.6 | 9.4 | 4.9 | 12.1 | 13.1 | 7.5 | 8.3 | 11.8 | 6.3 | 15.2 | 15.0 |
| ***Reliability*** | | 5 out of 20 times are delayed | 5 out of 20 times are delayed | 8 out of 20 services are delayed | 6 out of 20 services are delayed | 5 out of 20 services are delayed | 2 out of 20 services are delayed | 3 out of 20 times are delayed | 3 out of 20 times are delayed | 5 out of 20 services are delayed | 3 out of 20 services are delayed | 3 out of 20 services are delayed | 1 out of 20 services are delayed | 2 out of 20 times are delayed | 2 out of 20 times are delayed | 3 out of 20 services are delayed | 2 out of 20 services are delayed | 2 out of 20 services are delayed | It is rare that 1 out of 20 services are delayed |
| ***Start Time*** | | 7-10 AM | 7-10 AM | 7-10 AM | 7-10 AM | 7-10 AM | - | 11 AM-6 PM | 11 AM-6 PM | 11 AM-6 PM | 11 AM-6 PM | 11 AM-6 PM | - | 7PM-6AM | 7PM-6AM | 7PM-6AM | 7PM-6AM | 7PM-6AM | 7PM-6AM |
| ***Onboard experience*** | | - | - | 2 out of 6 seats taken | 3 out of 6 seats taken | 3 out of 6 seats taken | Picture | - | - | 3 out of 6 seats taken | 4 out of 6 seats taken | 4 out of 6 seats taken | Picture | - | - | 4 out of 6 seats taken | 5 out of 6 seats taken | Not reserved | Picture |