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CIRRELT-2019-39

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September 2019

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Performance Indicators of a Bus Intercity Service

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Abstract. With the decline of intercity travel by bus in Quebec, Canada, there is a need to better understand the demand for such service and its characteristics. Unfortunately, there is a lack of data coming from the industry, and there are few surveys that well describe the use of the bus services or even long-distance travel. In addition, travel demand models for intercity are often developed on the same basis than for urban mobility and there are few disaggregate information available. Actually, long-distance travel is often neglected in transportation policies. This study is a first step into better understanding intercity travel behaviors in Quebec. It benefits from a year-full of detailed data obtained from Orleans Express, a bus service provider in Quebec, Canada. The aim of the research is to better describe the service they provide in the Quebec province, provide some performance indicators and propose an intercity bus trip general model based on population density and seasonal variation. Results shows that most of the passengers are found on the high frequency Montreal-Quebec route, while regional routes have very low ridership. The demand is more stable on high-ridership, and vary according to the tourism season on lower ridership routes. Results of the model show that demand is higher on Fridays and Sundays, and from July to December (except November). Further researches will include service provided on other routes as well as results from a survey currently being developed to assess market share of bus on main corridors.

Keywords. Intercity bus, long-distance travel, ridership, origin-destination, forecasting, travel demand.

Acknowledgements. The authors wish to acknowledge the support of Orléans Express, which gracefully provided the data for this study.

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Bibliothèque et Archives Canada, 2019

INTRODUCTION

Intercity travel, also known as long distance travel, is often difficult to capture and study. Several reasons could explain the lack of information on these trips. First, typical travel surveys usually focus on daily urban trips. Also, operational data is often hard to access, as it often belongs to operators, who have no interest in sharing it. Finally, it is plainly because long-distance travel are difficult to measure the, both because the definition of interurban travel is fuzzy and since it is less related to regular behaviors. To properly assess the evolution of these trips, it is somewhat important to rely on ongoing studies, such as surveys of urban travel (the NHTS for example) found in many countries. In Quebec and Canada, there is currently no systematic data source on intercity travel [1]. Some sporadic surveys were made at the federal and provincial level, but, most of the time, they only cover a particular period or a particular mode of transport. The only systematic investigations in this regard is the “Travel Survey of Residents of Canada" [2], which covers travel within the country, and the “International Travel Survey" [3], which covers all trips outside Canada's borders. Unfortunately, these are created in the context of tourism studies on the matter of Canadian citizens and are not precise enough to be able to make a thorough study of the inter-urban mobility. Therefore, these trips are neglected and are not taken into account in the decision-making process. As a matter of fact, the environmental impact of these trips is not known.

Although there are no systematic sources of data on intercity travel in Quebec, we know that the interurban bus industry has been declining since the 1980s [4]. Although it experienced a slight increase in the years 2000-2008, it began to fall rapidly in 2009 [5] and has not increased since then. The situation is such that Orléans Express, currently the largest interurban bus company in Quebec, is considering cutting service and abolishing certain less busy routes, because maintaining these services is too expensive [6]. With the lack of information on the status of intercity transportation, bus carriers are currently at an impasse: they must either increase fares or cut services, and neither solution would be a benefit for the travellers.

Therefore, there is an urgent need to analyze the intercity transportation in Quebec. The lack of data on long distance trips makes it difficult to develop strategies to address the difficulties that bus industry faces, because the required information on travel demand is not available. In a context where the population is increasingly mobile and where we ponder the relevance of major projects such as a possible high-speed train between the cities of Montreal and Quebec, we will have, sooner or later, to question the role that take these trips play in the overall mobility in the province.

Objective

The purpose of this study is to better understand intercity transportation by bus in Quebec using data from the most important bus service provider: Orleans Express. Using this data, the aim is to:

- describe the use of the service in the different corridors;
- propose performance indicators that will assess, among other uses, the utilization rate, the temporal variability of usage of the buses and typical patterns (similarity in the days, regularity);
- propose a model of travel demand generation.

With the measures developed in this study, the bus companies in Quebec will be in a better position to plan and diagnose supply and demand in their corridors and figure strategies to better meet the needs of the travellers. Hopefully, these results, along with upcoming ones, will allow the industry to better highlight and address the challenges raised by the decline in bus traffic in the last years.

The paper first presents a literature review on intercity travel, then presents the general methodology of the study, mainly the information system and the preparation of the travel demand generation model. Next, there is a description of the intercity network used as case study. After that, there is a descriptive analysis based on the performance indicators of the network. Then, the results of the modeling of travel demand are exposed. Finally, the paper concludes on further research perspectives on intercity travel.

LITERATURE REVIEW

When we look at the state of research on long-distance travel demand models, we quickly conclude that there is not much differences with respect to those found in urban mobility. Actually, inter-urban mobility is often regarded in the same way as urban mobility and uses the same references and formulas, a situation that has been persistent for several decades [7,8]. There are no specific reasons why the models should not evolve; but the difficulty to define long distance, to obtain quality data [9] and to coordinate so many actors (as the private sector often a significant presence) may be part of the explanation [10].

The process in an intercity travel demand model consist of three stages: a direct demand model (or total demand), a mode split model and an assignment mode, in a process similar to the four-step model used in urban settings [10]. In the last years, a lot of emphasis was put on mode split models.

Most of the mode split models fall into multinomial logit models or nested logit models. The traditional mode split model is the multinomial logit models which has been used for a long time, mainly because of its simplicity, ease of estimation and interpret [11]. However, Forinash and Koppelman [11] have compared these two forms of models and found that the nested structure is beneficial to compare the effect of the change in the level of service of a mode on another mode, whereas in the multinomial logit model, the change in the mode of travel doesn't affect the probability of choosing another mode (a problem which is called the "independence of irrelevent alternatives"). Thus, nested logit models have been found to be superior with bus-train or car-train nests. Other models which have been developped are heteroscedastic extreme value models of intercity mode choice, which was proposed as a way to overcome the problem of independence of irrelevent alternatives [12], and a Nested Logit model with Paired Combinational Logit, Cross-Nested Logit and Product Differentiation Model [13], which was applied in the Montreal-Toronto corridor in prevision of a future high-speed rail. These models are also hard to transfer in different situations, meaning that they ideally have to be calibrated before they are applied in different settings [14].

These models are mostly agregate intercity passenger models, and disagregate models (calibrated on data concerning the individual travellers' behaviour derived from assumptions on their decision-making process) are rare [8]. The difficulty of obtaining sufficient quality data explains the absence of such model, and the application of these model have been limited. Most of the travel demand models also fail to take induced travel into account in their forecasting, because the conventional methods are not able to capture the effect of the travel time reduction caused by the improvement of the travel environnement [15].

All these experiments use indicators to measure the effectiveness of their model, but the researches on performance indicators is not more advanced than the ones on the travel demand models. The scale on which these models operate is relatively high, and the quantity of data is often not sufficient to make a precise model. Most of the models available in the litterature will simply determine the level of service, because of their strong influence in mode choice decision [8]. The TCRP Report 88 lists over 130 families of measures combining over 400 indicators [16]. Needless to say, only a number of them can be applied for measuring performance in the case of intercity bus travel (See Table 1 for examples). The performance indicators for interurban travel do not differ greatly from the ones used for short distance travel, but certain ones will have a greater or smaller significance. The travel time, for instance, will not necessarily be as important in mode choice, because the number of alternatives for intercity trips is limited.

Table 1: Various performance indicators [16]

Trips per day (service frequency)	Passengers per kilometer
Travel time	Passengers-kilometers per seat kilometers
Travel time ratio	Reliability of the service
Price for a one-way ride	Service hours
Number of transfers	Customer satisfaction
Waiting time	Accessibility
Vehicles per kilometer	Service coverage

CASE STUDY

For this study, data on the ridership on all the routes from the year 2012 was provided by Orléans Express. Figure 1 present the network operated by this company. The data lists all the trips made over this period of time. Some 216,333 records of boarding and alighting sorted by trip, hour of departure, origin and destination are available. The trip is herein related to a single directional bus run, that can be multiple within a single route during a day. The number of passengers for the entire trip is known as well. In addition, there is data for each boarding-alighting pair (called "segments"). This is described by the bus stop of origin and the bus stop of destination, plus the number of passengers for this pair. For the purposes of this study, additional data was inputted in the tables, namely an ID created for each stop, their coordinates and the density of the population within 5 km² and 10 km² of the station.

Table 2 presents a sample data and helps to understand the available information. For instance, trip 0901 of route 0010 occurred on January 1st, 2012. The trip is from Montreal to Quebec, with a total of 50 passengers. The stop sequence of this trip is Montreal – Longueil - Ste-Foy - Quebec. Passengers are divided into 4 segments (which may overlap), totalling 50.

Table 2. Sample data

Date	Day of week	Route #	Trip #	Trip origin	Trip destination	# of trip passengers	Segment origin	Segment destination	# of segment passengers
2012-1-1	Sun	0010	0901	Montreal	Quebec	50	Montreal	Ste. Foy	15
2012-1-1	Sun	0010	0901	Montreal	Quebec	50	Montreal	Quebec	25
2012-1-1	Sun	0010	0901	Montreal	Quebec	50	Longueuil	Ste. Foy	5
2012-1-1	Sun	0010	0901	Montreal	Quebec	50	Longueuil	Quebec	5

The richness of this data allows us to find the passenger load on each segment of a trip; however, the origin and destination pairs are not sorted according to the bus stop sequence. To effectively process the data, each origin and destination pair has to be sorted by point of origin, but the access and egress are calculated simply by looking at the number of passengers for each OD pair. The distances between the stops are not available from the database, although a less accurate distance is calculated by using the coordinates and straight line between the OD points.

BACKGROUND

In Quebec, intercity transportation is mainly composed of private cars (88%) and coach's trips (6%) [2]. Quebec's network of intercity buses covers almost the entire territory (with the exception of the extreme north of the province). Quebec's interurban bus industry is one of the most regulated in Canada, and the law specifies that a carrier needs to purchase a licence to operate on a specific route, and only one licence per route is available (service exclusivity). In the case of this study, Orléans Express has the right to operate the routes from Montreal to Québec, Rimouski, Trois-Rivières, La Tuque, Thetford-Mines and all of the Gaspesian Peninsula.

Orléans Express' network consists of nine routes servicing five corridors (see Figure 1):

- Centre-du-Québec: This corridor links Montreal to Thetford Mines and has only one route, which also makes the connection to Quebec City. The first half of the corridor shares some stops with the Montreal-Quebec corridor. This route also passes through the cities of Drummondville and Victoriaville in the middle of the way, which are the biggest cities on that corridor.
- Montreal-Quebec: This corridor is the busiest one for interurban bus travel in the whole province. It is situated on Highway 20 (A20), one of the two freeways connecting Montreal to Quebec City. Three routes pass by this corridor, and most service is express.
- Mauricie: This corridor is on the second main road connecting Montreal to Quebec, the A40, on the north shore of Saint-Lawrence river. One follows the A40 through Trois-Rivières, a major city in Quebec, and the other goes from Trois-Rivières to La Tuque. Due to the low traffic, Orléans Express is presently considering removing the "Trois-Rivière – La Tuque" route completely.
- Bas-Saint-Laurent: This corridor follows highway 132. One route passes through it, connecting Quebec, Rivière-du-Loup and Rimouski.
- Gaspésie: This corridor follows highway 132 around the Gaspé Peninsula. The two routes that pass there have the lowest traffic and have a large number of stops where very few people board the bus. Orléans Express is presently considering reducing the service on these routes.

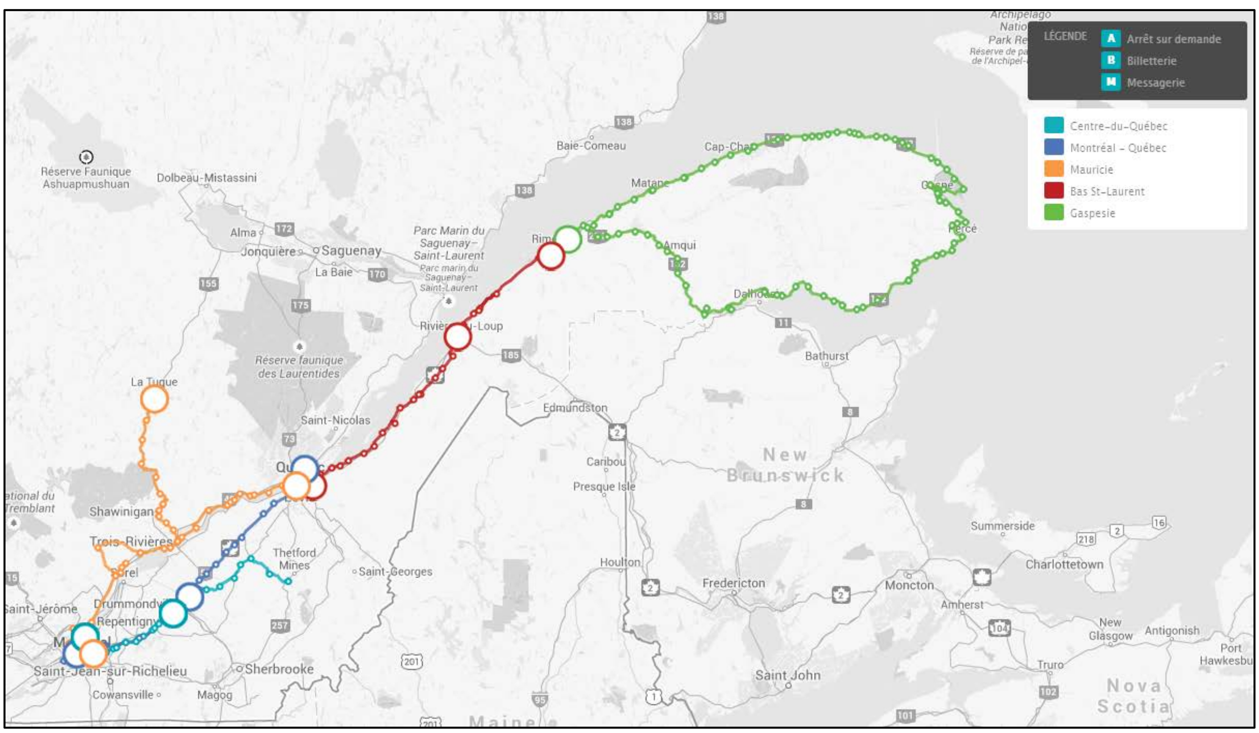

Figure 1. Overview of Orléans Express network

DESCRIPTIVE ANALYSIS

This section proposes a descriptive analysis of the network, looking at total, monthly and weekly ridership on the route. There is also an emphasis on the major origin-destination pairs.

Total ridership

As it was written previously, the route with the largest ridership is the Montréal-Québec route, by a large margin (see Figure 2). These numbers could be explained by the fact that these cities are the largest in the province (the Greater Montreal Area gathers half of the provincial population), and they are also major transportation hubs: most of the interurban buses across the province do a stop in either of these areas, so people have to transfer there to take another bus route. Half of the routes have a ridership lower than 50,000 passengers per year, and the ridership on the Montréal-Thetford Mines routes isn't that much higher too. The routes with the lowest number of passengers are the routes 60 and 68 in Gaspésie, the local Montreal-Quebec route (248) and the Trois-Rivières-La Tuque route (43). These last four routes attract less than 100 passengers per day on average, the lowest being route 43 with only 37 passengers per day.

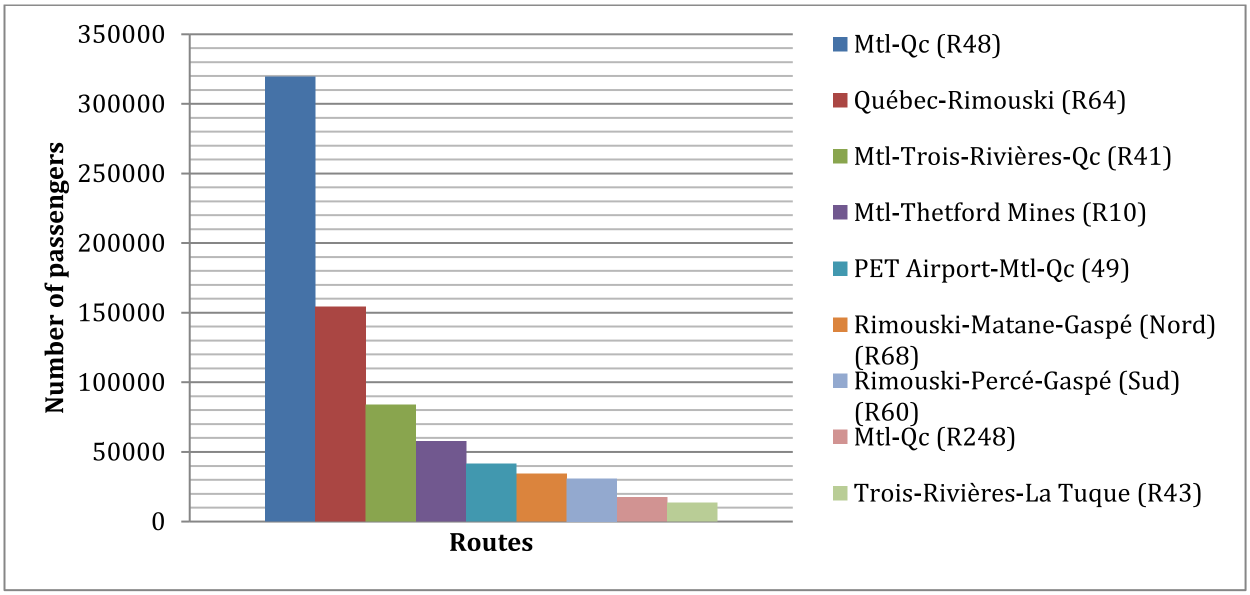

Figure 2. Total route ridership for year 2012

Monthly ridership

During the winter, ridership is stable across the routes: we can assume that the January is the outcome of the New Year holidays (visits to family and friends) and other vacations, while the peak in March is mostly due to the spring break (Figure 3); this can be verified by looking at the day-to-day data. During spring, there are no significant fluctuations, apart from a drop of ridership for the three less used routes. These same routes, during the summer, have a more important increase than the other routes. The traffic in the routes passing through Gaspésie is maybe due to the fact that it is a touristic spot, and that since a lot of the industries in the peninsula depend on seasonal jobs, it makes sense that there is more activity during summer. There is a sudden drop in September, suggesting that the beginning of the school year has much influence on ridership, while the increase in October is correlated with the Thanksgiving holiday in Canada as well as school break. The month of November has the lowest traffic of the year for most of the routes. The figure also reveals that the fewer passengers a route has, the more the traffic will fluctuate throughout the year. The busiest route, Montreal-Quebec, also fluctuates through the year, but it is more stable than the others, probably due to business interactions in the corridor.

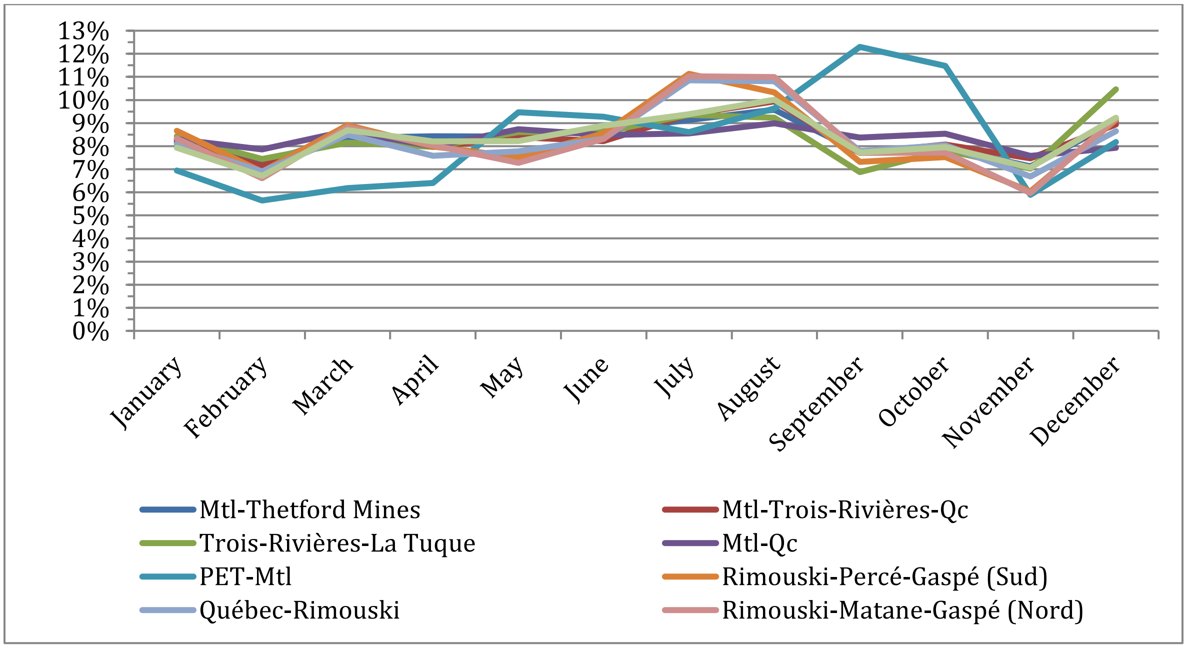

Figure 3. Monthly ridership on each route

Weekly ridership

Contrary to the monthly traffic, the weekly patterns are more synchronized (see Figure 4). The busiest days are generally Fridays and Sundays, and the sudden drop in traffic in Saturday suggests that most of the trips made Friday are overnight trips, with the return trip being made Sunday. After the weekend, the traffic steadily goes down where it reaches a minimum on Wednesdays. Since the majority of interurban trips are either for vacations or visits to friends and family (or business for important corridors), it makes sense that the days in the middle of the week are the ones where the traffic is the lowest. Once again, the routes that have the highest traffic are the most stable, as it is made clear by the Montreal-Quebec route, whose curve in Figure 4 passes right in the middle of the graphic.

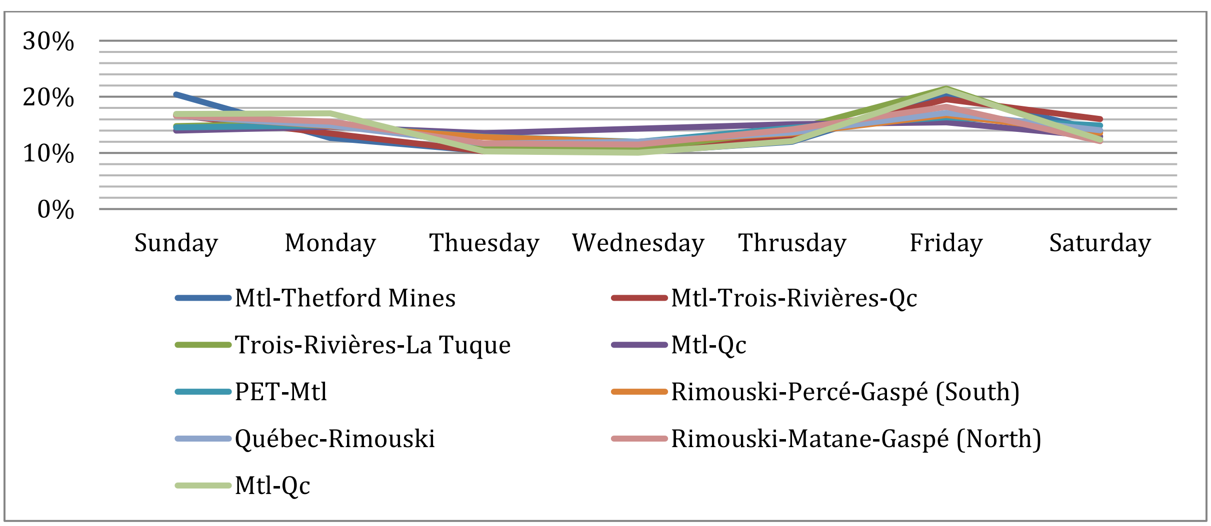

Figure 4. Ridership by day of week

Origins and destinations

The ten most frequent OD pairs represent 62.4% of all trips. Travel between the cities of Montreal and Quebec alone (including Sainte-Foy) represent 45.5% of all trips made by passengers on the network. The Montreal-Quebec City corridor is the busiest corridor, without even counting trips via other routes connecting these two cities (A20 and A40). In Table 3, it can be seen that each pair is immediately followed by its opposite, which is expected because each trip described is a one-way trip, and usually people will take the same transportation mode to return home. Often, however, the number of trips in each direction does not coincide.

Table 3: Ten most frequent OD pairs on Orléans Express' network

Origin	Destination	Number of passengers (2012 year)	% of total passengers
Montreal	Quebec	154821	13.6%
Quebec	Montreal	140631	12.4%
Sainte-Foy	Montreal	117991	10.4%
Montreal	Sainte-Foy	104764	9.2%
Montreal	Trois-Rivières	42749	3.8%
Trois-Rivières	Montreal	41554	3.6%
Sainte-Foy	Rimouski	32562	2.9%
Rimouski	Sainte-Foy	31949	2.8%
Montreal	Pierre-Eliot-Trudeau Airport	24408	2.1%
Pierre-Eliot-Trudeau Airport	Montreal	18602	1.6%

Number of passengers by bus trip

As seen in the analysis of the monthly and weekly ridership (see Table 4), the number of passengers will fluctuate depending on the time of year, the days of the week and the different holidays throughout the year. However, the number of trips made each day for each route is not the same depending on the route and the day of the week (and sometimes the season), as certain routes will have a higher number of trips, like the buses on the Montreal-Quebec route (R48) that do an average of 865 trips par month, while some others will have a really low number of trips, like the Trois-Rivières-La Tuque route (R49), that has an average of 109 trips per month.

Table 4: Average number of passengers by bus trip by route, by month and by day

Route/ Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Yearly
10	18.2	17.3	18.5	18.8	18.8	19.6	20.6	21.3	17.8	17.7	17.3	19.9	**18.8**
41	20.5	19.0	21.1	20.1	20.8	21.0	22.8	24.5	19.3	19.8	19.2	23.6	**21.0**
43	10.1	9.0	9.8	10.3	10.3	10.6	11.5	11.0	8.8	9.2	8.8	12.8	**10.2**
48	29.8	30.2	31.2	30.1	32.3	32.4	31.3	32.5	31.4	31.0	28.8	28.7	**30.8**
49	9.5	8.3	7.2	7.4	10.2	10.3	9.3	10.2	13.4	12.5	7.0	9.2	**9.6**
60	21.5	18.3	22.0	18.9	18.7	21.6	27.2	26.1	18.6	20.2	17.4	23.7	**21.2**
64	25.4	23.1	27.3	25.3	24.9	27.3	34.0	34.2	25.3	25.6	22.7	27.6	**26.9**
68	17.4	14.9	18.5	17.4	15.2	18.2	22.7	22.9	17.3	16.3	13.9	19.7	**17.9**
248	24.4	21.8	26.2	27.1	25.2	27.8	28.8	30.2	24.6	24.5	23.4	30.5	**26.2**
All routes	22.5	21.4	22.9	21.8	22.7	23.6	25.2	26.0	22.7	22.6	20.4	23.1	

DEMAND MODEL

The previous descriptive figures are confirmed by a simple trip production model estimated using daily boardings at each station. Using yearly data, a station-based dataset was prepared using daily boardings in order to observe yearly and weekly variations, incidence of population density around the stations as well as supply levels. In addition to demand indicators and temporal circumstances (day of the week and month of the year), two variables were introduced in the model:

- Population density within a 5 km ray from the station. This variable act as a proxy to identify if the station in located in an urban or suburban setting.
- Number of runs leaving the station per day. This variable takes into account the availability of service at the station.

A correlation study between the available variables was conducted to confirm which ones to include in the model. At first, two density variables were estimated for each station (within 5 and 10 km ray) but the two were highly correlated. Only the one providing the best contribution to the model was kept. No other significant correlation between independent variables was observed.

A simple multiple regression model was estimated under the assumption that the contribution of each variable was linear. Month and day variables were converted into dummy to simplify interpretation. The results of the model are presented at Table 5. The estimation benefited from more than 61 000 observations (one observation per day and station). The model explains some 40% of the variability of daily boardings at stations (similar results are obtained for alighting at stations).

Table 5: Results of the trip generation model (boardings per station per day)

				Number of observations	61022
				R-squared	0.393
Variable	**Coefficient**	**t**	**P>|t|**	**Mean Value**	**Avg impact**
Daily runs	5.9835	64.27	0.000	2.5713	15.3855
Population density (5 km2)	0.0992	162.40	0.000	166.9147	16.5597
Day of the week (ref: Tuesday, Wednesday, Saturday)					
Monday	2.4007	2.01	0.045	0.1452	0.3486
Thursday	2.7439	2.28	0.023	0.1424	0.3908
Friday	12.3718	10.27	0.000	0.1424	1.7618
Sunday	6.4858	5.42	0.000	0.1454	0.9430
Month of the year (ref: January, February, April, Novembre)					
March	2.1188	1.38	0.167	0.0828	0.1754
May	6.6630	4.42	0.000	0.0864	0.5754
June	3.8814	2.54	0.011	0.0836	0.3244
July	15.5863	10.33	0.000	0.0865	1.3486
August	11.0267	7.33	0.000	0.0869	0.9579
September	10.2438	6.71	0.000	0.0841	0.8612
October	18.8818	12.14	0.000	0.0813	1.5348
December	18.7016	12.40	0.000	0.0879	1.6436
_cons	-18.2004	-20.79	0.000		-18.2004
				Average daily boardings per station	24.6102739

CONCLUSION

This study is first step towards a better understanding of the intercity travel in Quebec, Canada. The work benefited from a year-full data from the most important bus service provider in Quebec, Orleans Express. The disaggregate data permitted to examine each route of the network, as well as the main origin-destination pairs. Results showed that the most important route (from Montreal to Quebec) has a stable ridership through the months and the days of the week, while low ridership routes are more dependent on tourism and seasonal fluctuations. A bus travel demand model is proposed and has described the trends observed in the descriptive analysis.

This work brings further research perspectives on intercity travel. First, there is a need to structure data from other bus providers to obtain the whole situation in Quebec. Next, an intercity travel survey will be conducted to gather a portrait of all the modes involved. Responses will help to better assess the market for intercity bus service. The aim is to provide demand and supply management tools for the bus operators.

ACKNOWLEDGMENTS

The authors wish to acknowledge the support of Orléans Express, which gracefully provided the data for this study.

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