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Travel demand forecasting and TDM measures: the example of Montreal's south shore, 2001-2021

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Abstract

Based on an extensive study completed for the Department of Transportation of the province of Quebec (DTQ), Canada, in 2002, the paper presents a case study of travel demand forecasting in the Montreal Metropolitan Area (MMA) between the South Shore and the rest of the RMM (mainly the Island of Montreal). The main objective was to diagnose the need or not of new infrastructures (new bridge, Light Rail Transit, etc.) vs. Travel Demand Management (TDM) measures to solve the problem of the growing congestion on the bridges. Starting from the medium scenario of morning peak travel demand for 2001-2021 produced by the DTQ, simulations were made to measure the possible impact of various TDM measures, derived from a review of the literature, as well as the combination of TDM measures and new mass transit infrastructures. The findings show that the strong ageing trends will have a natural tendency to reduce the past tendencies of rising global mobility and motorization, and we could even see, starting 2011, diminishing demand especially if strong TDM measures are implemented. The combination of various TDM measures could have a significant effect on future travel demand and appears to be a realistic alternative to the implementation of new infrastructures.

1 Introduction

The answer to growing congestion is generally to augment the capacity, by building new roads or bridges. There are, however, other solutions to modify mobility patterns. We will present the results of a study realized for the DTQ on the possible impact of TDM measures and new infrastructures to solve the problems of growing congestion between the South Shore and the Island of Montreal at the horizon 2021 [1]. Other studies were completed at the same time, such as the impact of land use management on mobility patterns (Lewis, Barcelo et Larrivée [2]).

The study [1] was threefold: 1. A review of the literature on the impact of TDM measures and new infrastructures; 2. A study of the evolution of travel demand in Montreal for 1987-1998 from O-D surveys, and a review of long term (2001-2021) forecasts made by the DTQ for the AM peak period [3]; 3. And, finally, an analysis of the feasibility of various TDM measures in the Montreal case and the elaboration of various simulations of such an impact for 2021.

The actual context is growing congestion on the bridges between the South Shore and Montreal. Demographic factors are important in travel demand forecasting (Bussière & Madre [4] and Bussière, Armoogum & Madre [5]). With ageing, mobility diminishes as well as peak hour work trips (Bussière [6]). The projections of population in the MMA for 2021 show a combination of slow growth and strong ageing. In the South Shore the global projected population growth is of 4.48% between 2001-2011 and 2.39% for 2011-2021 for a total of 6.98% ; the proportion of 65+ will reach 18.0% in 2021 compared to 13.4% in 2011 and 10.3% in 2001 [7]. The forecasts of travel demand between the South Shore and the rest of the MMA for morning peak period made by DTQ show growing congestion until 2011, with a possible calming down for the subsequent years due to slow demographic growth and ageing, as well as an increasing autonomy of the South Shore. We may even see diminishing demand during morning peak hours (6h00-9h00) after 2011, even though the part of public transit would diminish in favor of the automobile. This does not mean that congestion will necessarily diminish, as the future level of congestion will also depend on transportation of goods, which is not analyzed here.

In comparison with other urban areas of North America, the market share of public transportation is relatively high, even though it follows a decreasing trend (14% in 1998 vs. 24% in 1974). The share for transit is often very low for trips with a destination outside the centers of activities, and it is these trips that augment most. The growing autonomy of the South Shore would furthermore need more public transportation supply for east-west South Shore trips, which will have a tendency to augment.

TDM has for objective to modify behavior and reduce car use, mainly during peak hours. These measures, often costless, may affect various aspects of mobility: the need to make a trip, modal choice, choice of itinerary, or choice of the time of the displacement. Among some of the most common TDM measures, we can mention: carpooling, tax measures and road pricing, telecommuting, flexible hours. The most efficient measures are those affecting the price of the trip (road pricing, parking fees, etc.) or the supply (supply of parking, for example). Employer programs of carpooling can also be successful. Even though each of these measures may appear to have little impact, a combination of these measures may make the difference.

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2 Brief review the literature on TDM measures

Telecommuting for autonomous or salaried workers may reduce trips during the AM peak, but much less than what was announced in the 1990s. Telecommuting is popular among employees but an important constraint to its development is the resistance of employers to encourage it and the difficulties of implementation in many sectors (retail trade, for ex.). The increase in autonomous workers cuts a certain amount of trips during the AM peak, but not all of them since the autonomous workers may have, at times, to meet a client or a supplier (Bussière, Lewis, Thomas, [8]). Most of the gains to be expected from flexible hours have already been obtained, these measures, having been implemented in the 1980s and 1990s. The result was a lengthening of the peak period. There is, however, a limit to its extension due to social constraints: hours of schools and nursery, etc... (Bussière, Lewis, Thomas [8]).

Carpooling may seem *a priori* an interesting measure but it is already quite high in Montreal compared to other cities, and its natural tendency is to diminish. Globally, in the MMA, the rate of occupation of private cars was of 1.27 in 1998 during the AM peak, a slight rise from 1987 (1.25). On the South Shore, the rate was of 1.25 in 1998, identical to the 1987 level. However, it should diminish, following the reduction in household size. It is the informal carpooling, with family members or friends, which is diminishing. Expansion of carpooling needs the implementation of formal programs to insure a grouping of work or study trips; these programs often need the support of large employers, which are not that numerous in the MMA. Reserved lanes also appear as an attractive solution, which works rather well in the central city but its capacity of expansion in turnpikes is rather limited, due to the network, which contains rarely more than three lanes.

At least in theory, the reduction of the number of parking spaces can be an efficient solution to induce modal transfer from cars to public transit, but its implementation is politically touchy. Even though it is difficult to reduce existing parking space, one may find it desirable to limit it in new implementations (Ferguson, [9]). It is not always easy to measure the adequacy between supply and demand of parking spaces. A proxy can be the ratio of the number of spaces to the number of jobs or of the population. Such a ratio would indicate that it is rather low in the central city and high in the suburbs (around 1). A reduction of parking spaces would be easier to implement in the suburbs, but not very realistic because of the absence of efficient public transportation.

The rise of the cost of parking could be an alternative, probably easier to implement, with good efficiency to reduce automobile trips, especially auto-driver. Parking costs are cheap in the MMA compared to other cities. For example, in Ottawa (Canada), supply of parking was greatly reduced downtown (only very short parking is permitted on the street) with a sensible rise in the price. Such measures, accompanied with a better supply of transit, had a positive impact on transit use to the centre of the city, even for persons living in the suburbs. A recent study for the MMA (Lemelin & Hamel, [10]; Lemelin, [11]) estimated that a tax of $1.00 per parking per day could induce a reduction up to 4% of autos during the AM peak. This sole reduction corresponds roughly to the rise in trips projected by the DTQ for the period 2001-2021. Indeed, TDM measures may have a significant impact.

The introduction of tolls on bridges between the South Shore and the Island of Montreal is periodically debated (Tellier, [12]). On one hand, it is seducing since it corresponds to the actual tendency of user-payer and simple of application. Such a measure may however have pervert effects on the economic attractiveness of the central city of Montreal in a context of pursuing urban sprawl. Without getting into the debate if a toll is justified to regulate traffic, or generate revenues for new infrastructures, we may say that a toll could be politically acceptable since it existed in the MMA prior to the mid 1970s. Other tolls of the type cordon line to enter the central city are also periodically discussed in the MMA but suffer the problem of implementation and competitiveness of the central city.

A gasoline tax is often seen as an alternative solution to tolls (or for parking regulation). It is however different in the sense that it is a more universal measure, non discriminating on origins or destinations but only on distance traveled and the level of gasoline consumption. However, the level of taxation in the Province of Quebec is already one of the highest in North America and therefore the possibility to increase gasoline taxes appears to be very limited.

Solutions for better mobility in the future may need more than one isolated measure, but a combination of measures. TDM measures combined with a better supply of public transit between the South Shore and the Island of Montreal will be discussed in the next section.

3 Presentation of the simulation model and scenarios

This section presents various simulations of the possible impacts of TDM and new public transport infrastructures for the trips from the South Shore to the rest of the MMA during AM peak period (6h00-9h00). The simulations are based on the trend model of the DTQ for the period 2001-2011-2021, and they can be viewed as a sensitivity exercise to measure possible impacts of TDM measures and new public infrastructures vs. a trend scenario. The impact of various measures was derived from the literature.

In such a simulation exercise, the estimation of the impacts of measures which reduce peak travel demand (telecommuting, flexible hours, autonomous work) is rather easy, since these measures induce a diminution of demand. The main difficulty, for calibration, is to take into account the modal transfers induced by various TDM measures (toll, carpooling, etc.). In such a case, the results obtained from the literature, for example in terms of variation in % points of one modal choice, cannot be applied directly, since these rates depend on the modal split or relative proportion of each mode, which varies enormously from one city to another. Hence, we translated these variations (i.e., a diminution of x% of auto driver inducing a y% transfer in public transit) in terms of volumes of trips (a diminution of x% of auto driver, in the Montreal context would correspond to n trips), which we then distributed into two parts: 1- Distribution in volumes for each mode receiving the modal shift, according to their weight among total the modes receiving; 2- Calculation of the % for each mode receiver,

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n trips/total trips for the modes receivers. This % permits to calculate directly the modal shift for each TDM measure. It takes a plus (receiver) or negative (debit) sign. These % rates constitute the calibration matrix which measures the impact of the modal shift for each measure of TDM and for each mode. These rates are additive and their sum, for each TDM measure, permits to calculate what we can call an *operator*, or a coefficient which gives us the cumulative impact of each TDM measure by mode.

For each of the 12 corridors between the South Shore and the rest of the MMA (bridges, metro, tunnel) the simulation model was disaggregated into 5 modes, 10 TDM measures and one measure of supply (a new LRT between the South Shore and Montreal Island): autonomous work, telecommuting, flexible hours, carpool (without reserved lanes), reserved lanes for carpool, reserved lanes for buses, parking (diminution of the spaces), parking (rise of cost), tolls on bridges, gasoline tax, and finally the implementation of a LRT.

3.1 The 5 scenarios

Five scenarios will be presented, 2 scenarios to evaluate the impact of simple (soft) TDM measures, 2 scenarios to estimate the impact of road pricing, and a last scenario which combines TDM and the LRT. The simulations were made on the AM peak trips from the South Shore to the rest of the MMA:

- Scenario 1A: Simple TDM measures (low impact). It integrates a parking tax and an acceleration of telecommuting.
- Scenario 1B: Simple TDM measures (strong impact). This scenario is based on stronger hypothesis on the natural tendencies (autonomous workers, telecommuting, flexible hours) and adds carpool (formal, but without the obligation of the enterprises to implement such programs) and a stronger tax on parking.
- Scenario 2A: Toll (low) and simple measures of TDM. Hypothesis of scenario 1A plus low toll on bridges.
- Scenario 2B: Toll (high) and simple TDM measures. Hypothesis of scenario 1A, plus a high toll on bridges.
- Scenario 3: TDM measures and a LRT. Hypothesis of scenario 1A, plus the introduction of a LRT. Supposes the elimination of the actual reserved lane on the Champlain bridge and a rise of 25 % of transit clientele (transfer from the auto mode) in this corridor. Table 1 summarizes the hypothesis of the 5 scenarios.

3.2 The results

The simulations were based on the tend projections made by the DTQ. The predictive validity of the results will therefore depend on the validity of these projections. In any case, the exercise of sensitivity of various TDM measures in comparison to the trend scenario is valid. Table 2 gives the projections of the DTQ for AM peak period.

Table 1. Summary of the hypothesis of the 5 scenarios

Scenario	Type	Hypothesis - calibration
1A	soft TDM	/low impact of telecommuting applied to work trips (-0.015 * .80 = -.012) /medium parking tax adjusted to give -2% auto-d trips
1B	strong TDM	/strong impact of telecommuting (-.023 * .80= -.0184) /strong impact of autonomous work (-.029*.80 = -.0232 /high parking tax adjusted to give -4% auto-d trips /high impact of flexible hours (-0.11*.80 = -.0088) /carpooling - maintain of nb of pass per car in 2021 at the level of 2001 (which gives 1502 additional auto-p in 2021, i.e. an increase of 1.50% of carpoolers instead of a diminution of 18.34%)
2A	soft TDM & low toll	/hypothesis of scenario 1A /moderate toll on bridges inducing a diminution of 5% of trips auto-d from the South Shore to the rest of the MMA
2B	soft TDM & high toll	/hypothesis of scenario 1A /high toll inducing a diminution of 10% of trips auto-d from the South Shore to the rest of the MMA
3	soft TDM & LRT	/hypothesis of scenario 1A /introduction of a LRT on the axis of Champlain Bridge /Supposes the elimination of the actual reserved lane on the Champlain bridge and a rise of 25 % of transit clientele (transfer from the auto mode) in this corridor, which was calibrated by a rate of 0.125 (since this corridor consists of around 50 % of the total transit trips from the South Shore)

The projections give a rise in auto-driver trips for the period 2001-2011 (+1.7%), followed by a decrease for 2011-2021 (-0.7%), which gives a slight increase for the whole period (+1.0%). For auto-passengers (excluding bi-modal trips) the rates are respectively of -11.2% and -8.1% for a total diminution of 18.3%. The public transit trips (excluding bi-modal) would diminish of 10.4% for 2001-2011 and of 10.8% for 2011-2021, which gives a total diminution of 5,744 trips (-20.1%). If we add bi-modal trips (auto-public transit) the diminution of public transit demand would reach 6,107 trips or -15.8% (we supposed that all bimodal trips corresponded to trips in public transit in the corridors South Shore - Rest of the MMA). This would mean that in 2021, there could be an additional capacity for public transit 6,000 trips during the AM peak between the South Shore and the rest of the MMA. This would give the opportunity to implement TDM measures favorable to a modal split from auto (driver and passenger) to public transit - an important potential of 16% of the traffic flow.

If we suppose in 2021 measures of TDM which would induce a transfer of mode of auto-driver to public transit of 6,000 the auto-driver trips would diminish by 6.4% instead of the 1.0% rise projected by the DTQ, a difference of 7.4 % points. This means that the period 2001-2021 could be a favorable moment to introduce TDM measures inducing the use of public transportation.

This could be done in various ways, as we can see by the results of the 5 scenarios (table 3). We can see that the results of the 5 scenarios go in the same direction, each with an increasing impact favorable to the public transportation. Even soft measures of TDM (Scenario 1A - telecommuting and parking tax)

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could be sufficient to inverse the tendency of rise of the auto trips. However the scenario 1A would also give a reduction in public transportation.

Table 2. Trips by mode of the South Shore towards the rest of the MMA, trend projections of the DTQ, 2001, 2011, 2021.

Mode	Trips			Variation					
				Volume			%		
	2001	2011	2021	2001-2011	2011-2021	2001-2021	2001-11	2011-21	2001-21
Auto D	80 886	82 251	81 699	13 651	-552	813	1.7	-0.7	1.0
Auto P	12 624	11 213	10 309	-1 284	-1 411	-904	-11.2	-8.1	-18.3
Transit alone	28 596	25 610	22 852	-2 986	-2 758	-5 744	-10.4	-10.8	-20.1
Transit + Auto D	6 156	6 398	6 525	242	127	369	3.9	2.0	6.0
Transit + Auto P	3 914	3 540	3 182	-374	-358	-732	-9.6	-10.1	-18.7
Transit total	38 666	35 548	32 559	-3 118	-2 989	-6 107	-8.1	-8.4	-15.8
Total	132 174	129 014	124 566	-3 160	-4 448	-7 608	-2.4	-3.5	-5.8

Source: Saint-Pierre et Thiffault, [3].

If we suppose in 2021 measures of TDM which would induce a transfer of mode of auto-driver to public transit of 6,000 the auto-driver trips would diminish by 6.4% instead of the 1.0% rise projected by the DTQ, a difference of 7.4 % points. This means that the period 2001-2021 could be a favorable moment to introduce TDM measures inducing the use of public transportation.

This could be done in various ways, as we can see by the results of the 5 scenarios (table 3). We can see that the results of the 5 scenarios go in the same direction, each with an increasing impact favorable to the public transportation. Even soft measures of TDM (Scenario 1A - telecommuting and parking tax) could be sufficient to inverse the tendency of rise of the auto trips. However the scenario 1A would also give a reduction in public transportation.

The impact of scenario 1B, which supposes more TDM measures (telecommuting, parking tax, flexible hours and carpooling) has a much stronger effect. But, even with this scenario, which can be considered as intermediate since it does not suppose an increase of supply of public transit, we would still observe a diminution of both auto and public transit trips. We can see here that even with rather simple TDM measures we could observe an increase of capacity on the road network which could alleviate congestion (if, however TDM measures are well dosed to prevent a rise in car use due to less congestion).

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Table 3. Impact of 5 scenarios on AM peak trips from the South Shore to the rest of the MMA, 2001 – 2021 and variation from trend projection DTQ 2021

SIMPLE MEASURES OF TDM

Scenario 1A: low impact of TDM measures

	Trips		Variation 2002-2021		Variation from trend	
	2001	2002	Volume	%	Volume	%
Auto D	80 886	79 085	-1 801	-2,2	-2 614	-3.2
Auto P	12 624	10 578	-2 046	-16.2	269	2.6
Transit	38 666	33 409	-5 257	-13.6	850	2.6
Total	132 174	123 072	-9 102	-6.9	-1 495	-1.2

Scenario 1B: high impact of TDM measures

	Trips		Variation 2002-2021		Variation from trend	
	2001	2002	Volume	%	Volume	%
Auto D	80 886	72 844	-8 042	-9.9	-8 855	-10.8
Auto P	12 624	12 630	6	0.0	2 321	22.5
Transit	38 666	32 815	-5 851	-15.1	256	0.8
Total	132 174	118 289	-13 885	-10.5	-6 278	-5.0

TOLL AND MEASURES OF TDM

Scenario 2A: low toll (with low impact of TDM measures)

	Trips		Variation 2002-2021		Variation from trend	
	2001	2002	Volume	%	Volume	%
Auto D	80 886	75 000	-5 886	-7.3	-6 699	-8.2
Auto P	12 624	11 561	-1 063	-8.4	1 252	12.1
Transit	38 666	36 512	-2 154	-5.6	3 953	12.1
Total	132 174	123 072	-9 102	-6.9	-1 495	-1.2

Scenario 2B: high toll (with high impact of TDM measures)

	Trips		Variation 2002-2021		Variation from trend	
	2001	2002	Volume	%	Volume	%
Auto D	80 886	70 915	-9 971	-12.3	-10 784	-13.2
Auto P	12 624	12 543	-81	-0.6	2 234	21.7
Transit	38 666	39 615	949	2.5	7 056	21.7
Total	132 174	123 072	-9 102	-6.9	-1 495	-1.2

LRT AND MEASURES OF TDM

Scenario 3: high impact of LRT (with low impact of TDM measures)

	Trips		Variation 2002-2021		Variation from trend	
	2001	2002	Volume	%	Volume	%
Auto D	80 886	68 872	-12 014	-14.9	-12 827	-15.7
Auto P	12 624	9 290	-3 334	-26.4	-1 019	-9.9
Transit	38 666	44 910	6 244	16.1	12 351	37.9
Total	132 174	123 072	-9 102	-6.9	-1 495	-1.2

The introduction of a toll (scenarios 2A and 2B) would be much more effective, especially if the toll is high. In such a case we could have an increase in public transit during the period (scenario 2B) but this rise (2.5%) could need increases in capacity to keep public transport competitive (i.e., better service). Finally, scenario 3, which combines TDM measures with the addition of a LRT shows a strong rise in public transportation. Most of the studies on the impact of LRT since the 1980s indicate a strong modal shift which, in certain cases, can reach 75 to 80 % of the traffic (Weyrich & Lind, [13]). More often it is lower, in the 25 % range. We suppose that the modal shift would be of this magnitude, which we think is a high scenario. With that hypothesis, the clientele for public transit would augment by around 6,000 persons at the horizon 2021 and auto trips would diminish by the double. We could say that the implementation of a LRT would give results similar to that of a toll on the bridges for the modal shift auto towards public transit, but the impact on total usage of public transit could even be greater with the LRT. It appears that only vigorous TDM measures like a toll or strong supply measures (a LRT) would permit to inverse the tendency of diminution of public transit usage but the trend of diminishing demand makes it more difficult to guarantee enough passengers to a LRT.

These simulations can give good insights on the usefulness and limits of TDM measures: 1. TDM can be cheap and easy to implement and can have a significant impact; 2. In the MMA case studied here, soft TDM measures appear sufficient to improve mobility between the South Shore and the rest of the MMA. However these measures will have less impact if the residual capacity on the road network increases, which could be the case at the horizon 2021; 3. The reduction of auto trips does not automatically mean the end of congestion on the bridges. The increase in trucking which we have seen in the past years should continue with pursued economic development and possibly with the e-retailing; 4. The implementation of a LRT (scenario 3) could bring a significant rise in public transit users only if we have a modal shift from auto. In a context of increasing capacity of the road network, this shift will be difficult to obtain without strong TDM measures as a parking tax or a toll on the bridges between the South Shore and the island of Montreal.

4 Conclusion

Mobility between the South Shore and the rest of the MMA has been deteriorating, with increased congestion during the last 20 or 30 years. Even though congestion in the MMA is less than many North American cities, new infrastructures have not been implemented since Expo 67. This situation could deteriorate during the next decade, but after 2011, we could see a reversing trend due to a low demographic growth and the impact of ageing, which has a negative impact on mobility, especially during the morning peak period. A comparison of the DTQ trend scenario of transportation demand for the period 2001-2011-2021 with various scenarios of TDM and the introduction of a LRT shows that improvement of mobility fluidity could be possible with the implementation of a combination of TDM measures without the need of new infrastructures. However, the implementation of a LRT would induce more public transit usage and improve fluidity of the road network. It would give room to maneuver for factors omitted in the analysis, as the probable rise in truck deliveries.

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