Who benefits from new transportation infrastructure? Evaluating social equity in transit provision in Montreal

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Transit provision has the potential to address several important societal goals such as reducing GHG emissions, cutting traffic congestion, spurring economic development, creating jobs, as well as giving access to destinations regardless of car ownership. Understanding who benefits from new transit projects is a key factor in analyzing the sustainability of a system. This article explores the potential effects of proposed transit infrastructure projects in the Montreal transportation plan on residents of socially disadvantaged neighborhoods in Montreal, Canada. A social disadvantage index is used to identify neighborhoods in need of attention. We then model accessibility and travel time changes as a result of proposed transit infrastructure. These two measures are used to quantify the benefits at the regional and personal scales. The Montreal transportation plan is relatively equitable, though some areas benefit much more than others at the regional scale as well as at the personal scale. Balancing economic, environmental, and equity goals of transit plans is a complex and challenging process. It is recommended that policy makers carefully consider who will benefit from transit improvements when prioritizing among projects at both the regional scale, through accessibility measures, and the personal scale through analysis of travel time improvements.

INTRODUCTION

A principal function of public transit is to provide accessibility to all members of society, particularly to those with limited mobility choices. As issues of equity and fairness gain importance in transportation planning, understanding who benefits from new and existing transit services has become an increasingly important topic. Transit providers, however, struggle to address two, often opposing goals: providing service that attracts new riders, while striving to better serve current users. Both environmental and economic goals tend to focus on attracting new riders, as replacing car trips has more emission-reducing and revenue-generating potential than improving service for current users. This dichotomy manifests itself in many North American regions as some municipalities prioritize suburban rail systems, for instance, over improved inner-city bus lines. That is not to imply that these decisions are easy to make, or that they are made in bad faith. Suburban rail has the potential to make significant reductions in GHG emissions if it succeeds in causing a mode change. However, the quality-of-life benefit to an inner-city resident with low job accessibility due to poor or unreliable public transit is minimal – apart from universal gains in air quality enjoyed by all residents.

This paper examines the extent to which proposed transit infrastructure projects in the City of Montreal, Canada transportation plan benefit the disadvantaged population. First, we identify neighbourhoods with both high levels of social (based on income, immigration status, and education levels) and transportation disadvantage (low levels of current job access). Then, accessibility to employment opportunities are modeled using both existing and new transit networks. A before and after comparison of the level of access and change in travel time will allow us to identify neighborhoods that will benefit the most from the new plan. Benefits from new transit projects are quantified as an increase in access to opportunities and decline in travel time to desired destinations. Accessibility measures concentrates on quantifying the benefits at the regional scale, while the travel time measures will concentrate on the personal scale. In short, this study tries to develop a methodology that can answer three research questions using readily available data and simple measures of land use and transportation interaction. The first question is; are increases in accessibility to jobs due to the implementation of transportation plans reasonably distributed throughout the socio-economic gradient? The second question is; do these

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jobs match with the labor market for socially disadvantaged populations? The third and last question; are decreases in travel time equitably distributed in the region?

LITERATURE REVIEW

In recent decades, urban transportation planning has shifted in focus from increasing infrastructure capacity for automobile traffic to broader policies with environmental and social dimensions (Hall 1997; Lindquist 1998; Banister and Gallent 1999; Jabareen 2006; Marsden, Lucas et al. 2007; Carmona and Sieh 2008). Plans now include goals that express principles of sustainable development such as improving air quality, reducing automobile dependency, and promoting active modes of transportation including public transit. However, while performance indicators and goals have become somewhat codified for environmental and economic goals of transit systems, equity goals lack clear appropriate indicators for measuring progress. If no measures exist to monitor progress toward certain goals, planners may be led away from them in the planning process or these goals may remain unaccounted for at the time of evaluation (Meyer and Miller 2000; Briassoulis 2001; Handy 2008). Goals that reflect principles of sustainable development rely on the integration of economic, social and environmental considerations and require a holistic approach when measuring performance (Carmona and Sieh 2008). Urban planners and engineers are in need of tools with which to evaluate plans and projects for goals that are less easily quantified. At the same time, indicators must be sufficiently simple and intuitively meaningful to be used in public forums and become widely accepted measures. In addition these measures should be applicable at various scales, personal and regional.

There is a long history of discussion about the meanings of "equity", "fairness", and "justice" in fields ranging from philosophy to economics. The ambiguity of the meanings of these concepts has in all likelihood led to confusion about what equity might mean to a transportation planner (Murray and Davis 2001). In the planning context, "equity planning" has come to mean a responsibility that planners have to "influence opinion, mobilize underrepresented constituencies, and advance and perhaps implement policies and programs that redistribute public and private resources to the poor and working class" (Metzger 1996 p. 113). In a transportation setting, this could refer to giving disadvantaged populations higher accessibility and more mobility choices – regardless of ability to pay, perhaps even at reduced

rate. This view, commonly known as "vertical equity" deliberately gives benefits to one group – the poor – and not others – those deemed to be well-served and/or with an ability to pay full price for a given service.

Findings from the 2001 National Household Travel Survey show clear correlations between income and transit use. Roughly 57% of all transit trips and 78% of bus and light rail trips are made by households with income less than $40,000, while only 13% of commuter rail trips are in this income category (Pucher and Renne 2003). However, while transit users are predominantly poor, it does not follow that transit provision always benefits poorer residents as common perception might imply. In many regions, in fact, it is just as likely that suburban residents enjoy new, efficient, and comfortable transit, while inner-city residents ride uncomfortable, unreliable and often times overcrowded bus lines. Los Angeles and Washington DC are examples of cities where research has shown this to be the case (Bae and Mayeres 2005). Also, wealthier individuals make much longer transit trips. As many transit providers either charge a flat fee for transit use or fares that are not truly related to distance, it is possible that poor users are "subsidizing" the rich (Bae and Mayeres 2005).

The role that public transit plays in providing access to job locations for those with limited mobility options has long been argued as a key goal in transit planning (Sanchez, Shen et al. 2004; Horner and Mefford 2005; Currie 2010). Recent transportation plan goals have also more explicitly addressed this. However, observers have identified the importance of measuring the different goals that coexist in any transit system. The difficulty is that these economic, environmental and equity goals are not always complementary, in fact they are often in direct opposition. Walker (2008), claims that there are two opposed "poles" in transport goals. One is based on the idea of patronage while the other is focused on coverage. Patronage goals are an integral of both economic and environmental focuses; more people using transit represents both more revenue and less people using more polluting modes. Coverage goals focus on providing service to those who need it the most regardless of whether the route is profitable or the level of patronage. In this view, environmental and economic goals of transit could lead planners to focus on capturing new riders at the expense of current transit users. Replacing car trips has more emission-reducing and revenue-generating potential – and is more easily measured. Coverage

goals, on the other hand would include such ideas as minimizing discrepancies in levels of accessibility amongst socio-economic, racial and immigrant status categories. While these two goals may not be mutually exclusive in all cases, Walker contends that they often lead to difficult decisions among transit route possibilities.

A large and growing body of work explores these tradeoffs between equity and other "traditional" transport goals (Murray and Davis 2001; Kwan and Weber 2003; Horner and Mefford 2005; Currie 2010; Grengs 2010). Municipalities can often find themselves attempting to serve low-density residential growth at the urban periphery while inner-city transit-dependent households are not given priority in transit plans. This could be related to regional transportation plan goals which focus more on mode-shift than providing and increasing access to current and future users.

Much of the work concerning levels of access to employment opportunities among socio-economic gradients is based on spatial mismatch theory (Kain 2004). The theory of spatial mismatch observes the separation between job locations and the workers with appropriate skill and education levels to fill them. Some evidence would suggest that low-income jobs are more spatially dispersed than specialized, high-paying jobs, and therefore easier to access for those without an automobile. However, past research has also noted that in many North American regions, low-income populations are concentrated in isolated urban areas, while appropriate job opportunities are predominantly – and increasingly – located in suburban areas. Recent work has shown that the issue may be more of a "modal mismatch", where the locations are not necessarily separated by geographic space as much as by difficulty of getting to a desired location by transit or active means. In other words, with a car, such job locations would be easily accessible (Grengs 2010).

Pickup and Giuliano (2005) describe a cycle where those without access to a vehicle are isolated from jobs and other services. This leads to further "area-based" social exclusion. Accordingly, it will be more difficult for them to afford a vehicle and increase their personal access to desired destinations. In particular, many newcomers to cities first locate in areas with low job access and near existing newcomers. This can lead not only to isolation based on mobility choices, but linguistic and social isolation as well. Apart from access to an individual's

employment, transit also offers a poor substitute to the automobile in finding and interviewing for potential job opportunities (Sanchez, Shen et al. 2004).

In perhaps an extreme example of favoring equity over environmental and economic goals, Grengs (2010) argues that offering subsidies to the poor in order to purchase automobiles is potentially a viable solution. He is careful to point out that this may only be true in certain circumstances. For example when transit system is underdeveloped and providing these subsidies could be a cheaper and more efficient solution. In conclusion, there is clearly a healthy debate over the extent to which transportation goals should focus on economic factors and cost-benefit analysis and issues of social welfare and equity.

METHODOLOGY

In order to measure changes in accessibility levels and travel time brought about by the projects proposed in the Montreal transportation plan (MTP), existing and proposed transit infrastructure are modeled in a Geographic Information System (GIS). The transit projects include the new Light Rail Transit system (LRT or Tram) lines, the rail link to the airport, extensions of the commuter rail and metro systems, the new Bus Rapid Transit (BRT) lines, and increased reliability and travel speeds for existing bus lines thanks to signal-priority measures and/or reserved lanes (See figure 1). We are conceptualizing transit in this research as primarily a mode to connect workers to their place of employment, particularly for those without other viable options and the extent to which the MTP will aid in this. The other important roles that transit may play in connecting people to shopping and social activities are not included in our analysis. Analyzing the effects of the MTP on these trips is complicated and difficult to model. This is due to several reasons, including the fact that these decisions may vary more by personal choices than economic necessity and the fact that social opportunities may not "cluster" the same way jobs might. This research will involve two phases of data preparation prior to the analysis phase. The first is identifying areas with high concentrations of social and transportation disadvantaged population. The second is generation of before and after MTP accessibility measures and travel time change matrixes.

The measure of accessibility used in quantifying the impact of the MTP is the cumulative opportunities measure. It is a simple measure to calculate and uses readily available data. In addition it is easily understood and communicated. It counts the number of opportunities that can be reached within a predefined travel distance or time (El-Geneidy and Levinson 2007). For example the number of jobs that can be reached by public transit within 30 minutes of travel time. A major advantage of this measure, beside the simplicity in explanation, is the high level of correlation with other complex measures like gravity based measures of accessibility (El-Geneidy and Levinson 2006). This measure is generated for both before and after periods. It was also generated for every project in the transportation plan. These measures of accessibility will enable the understanding of changes at the regional scale. However, we did use a more involved accessibility measure for identifying socially disadvantaged areas; this is explained below.

On average, in Canada, a one way transit trip is around 52 minutes (Turcotte 2005) . The 52 minutes comprises access time, waiting time, in-vehicle time, egress time and transfer time if a transfer was present. In our analysis we will use 30 minutes of in vehicle as the standard for the measures of accessibility, which is a reasonable approximation of what transit users are willing to spend on in-vehicle-time.

Finally, information related to home and work location of every person residing in the Montreal metropolitan region is obtained from Statistics Canada. Travel time using public transit is calculated for each individual before and after the implementation of the MTP. This is done by linking each zonal pair back to individuals. In this way, changes in travel times associated to every project in the MTP are calculated for each individual. This will enable a better understanding of the effect of changes at the individual level and creates a simple bridge between more data-intensive individual accessibility measures and zonal-based approaches.

Three indicators are explored to evaluate the extent to which the proposed projects in the MTP provide equitable access.

1. The impact of each transit project in the plan on areas shown to be socially disadvantaged in terms of accessibility to jobs with trips of 30 minutes in-vehicle time or less. This analysis will focus on jobs requiring a high school education or less.

2. The change in travel time to Montreal's 6 employment centers by transit from the identified disadvantaged areas.

3. The potential time savings based on actual current job locations (from detailed home and work location data from Statistics Canada).

Mapping, tables and statistical analysis are used to highlight the benefits and differences among neighborhoods and projects.

DATA

The unit of analysis is the Traffic Analysis Zone (TAZ) which was provided by the Québec Ministère des transports (MTQ). The MTQ also provided the research team with travel time information for transit that was generated by a travel demand modeling software. Employment and demographic information was extracted from the 2006 Census conducted by Statistics Canada, while the transit network information was received from the Société de Transport de Montreal (STM). Access to aggregated home and work location data was provided by the MTQ *Services des affaires socio-economiques*.

Simulated congested A.M. peak travel times were obtained from two different government agencies for transit travel times. In order to model the proposed projects, new travel time matrices were generated. A transit travel time matrix was generated in a GIS environment using each of the transit stops closest to each TAZ centroid as both origins and destinations. Travel times on the transit network were estimated on the basis of the average operating speed of each individual transit line using the prepared GIS transit network. This method assumes that there is no delay at a transfer between lines. To correct this, a linear regression model was built to compare the simulated travel times to the travel times provided by the MTQ. A second set of travel time matrices was generated based on in-vehicle travel time. Using travel times rather than distance greatly improves the realism of accessibility measures.

THE MONTREAL STUDY CONTEXT

Montreal is located on an island in the St-Lawrence River. Comparatively speaking, Montreal has developed in a rather sustainable fashion, with an average metropolitan population

density of about 6,000 persons per square mile of urbanized territory and with a modal share of 22% for public transit in the morning commute to work (Communauté métropolitaine de Montreal 2010). The city has a subway system which extends into two off-island suburbs and a suburban train system which reaches far into the metropolitan periphery. Both systems are focused on the CBD, where the majority of jobs are located. The other two largest employment centers are located elsewhere on the Island of Montreal; employment is growing in off-island suburbs as well (Shearmur 2006). Figure 1 shows the Montreal metropolitan region, along with the existing and proposed transit lines and the location of the 6 major job centers.
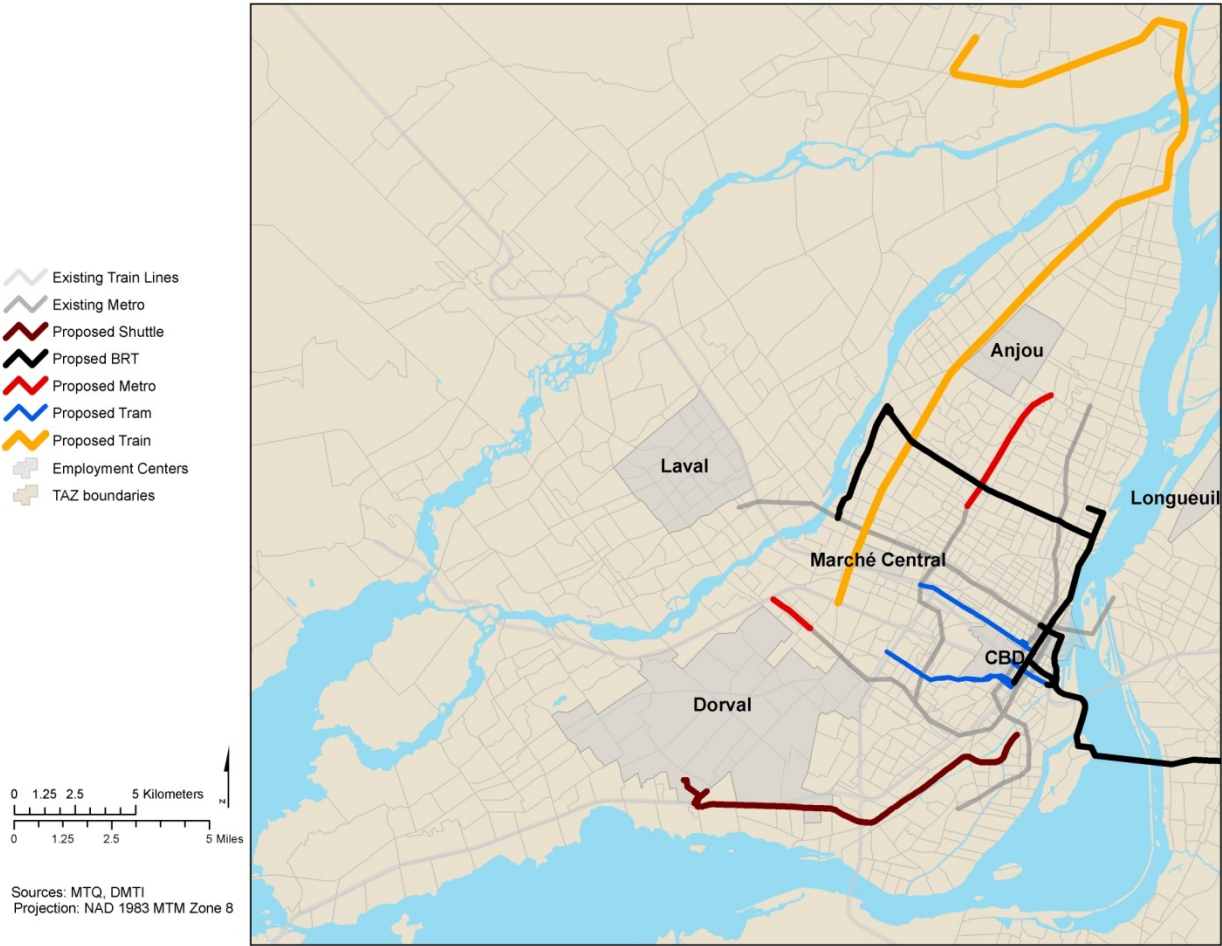

Figure 1: Study context with existing and proposed public transit projects and location of employment centers

The overarching goal of the MTP is to make public and active transportation the preferred modes of everyday travel in order to reduce automobile dependency and to meet other

sustainability aims (Ville de Montreal 2008). The MTP contains no performance measures or indicators to assess if projects will help make transit the preferred modes of travel. The authors of the plan present only one objective that can be easily measured: increase transit ridership by 8% by 2012, and by 26% by 2021. The remaining performance measures included in the plan are: variation in mode share, change in the volume of greenhouse-gas emissions, reduction in accident rates, and total transit-service hours (Ville de Montreal 2008). Equity issues are not explicitly addressed in the plan. Moreover, none of these measures can effectively help prioritize the various projects contained in the plan.

ANALYSIS

Socially Disadvantaged Population

As the main question is the extent to which socially-disadvantaged neighborhoods are served by present and proposed transit service, we first identified those neighborhoods most in need by using a composite index comprised of 4 indicators plus an employment accessibility measure. The indicators are: median household income, percentage of residents that are foreign-born, percentage of adults with high school education as the highest educational attainment, and percentage of residents who use transit for work trips. In addition to these four factors, we included a measure of accessibility to low-skill jobs requiring only a High School education accounting for competition from those of a similar education levels. This measure is known as the inverse balancing factors of the doubly constrained spatial interaction model measure of accessibility (Wilson 1971). The scores from all five indicators were standardized (Z)-score, a measure which determines how far (plus or minus) a given value is from the mean. These scores were then summed, giving a simple social disadvantage index. We then took the highest (worst) decile neighborhoods as the socially disadvantaged neighborhoods. Others have used much more elaborate indices, we choose to base ours on a simple method with precedence in the literature (Bauman, Silver et al. 2006).

In this manner, the identified socially disadvantaged areas are predominantly characterized by low income, transit dependent, immigrant households with low educational levels, who, in addition to these linguistic and material constraints, also have poor accessibility to employment positions that they are likely to be seeking. Figure 2 shows a map of socially

disadvantaged areas. While Table 1 shows mean values to highlight how these particular neighbourhoods differ from the regional average in these key indicators of social disadvantage and exclusion.
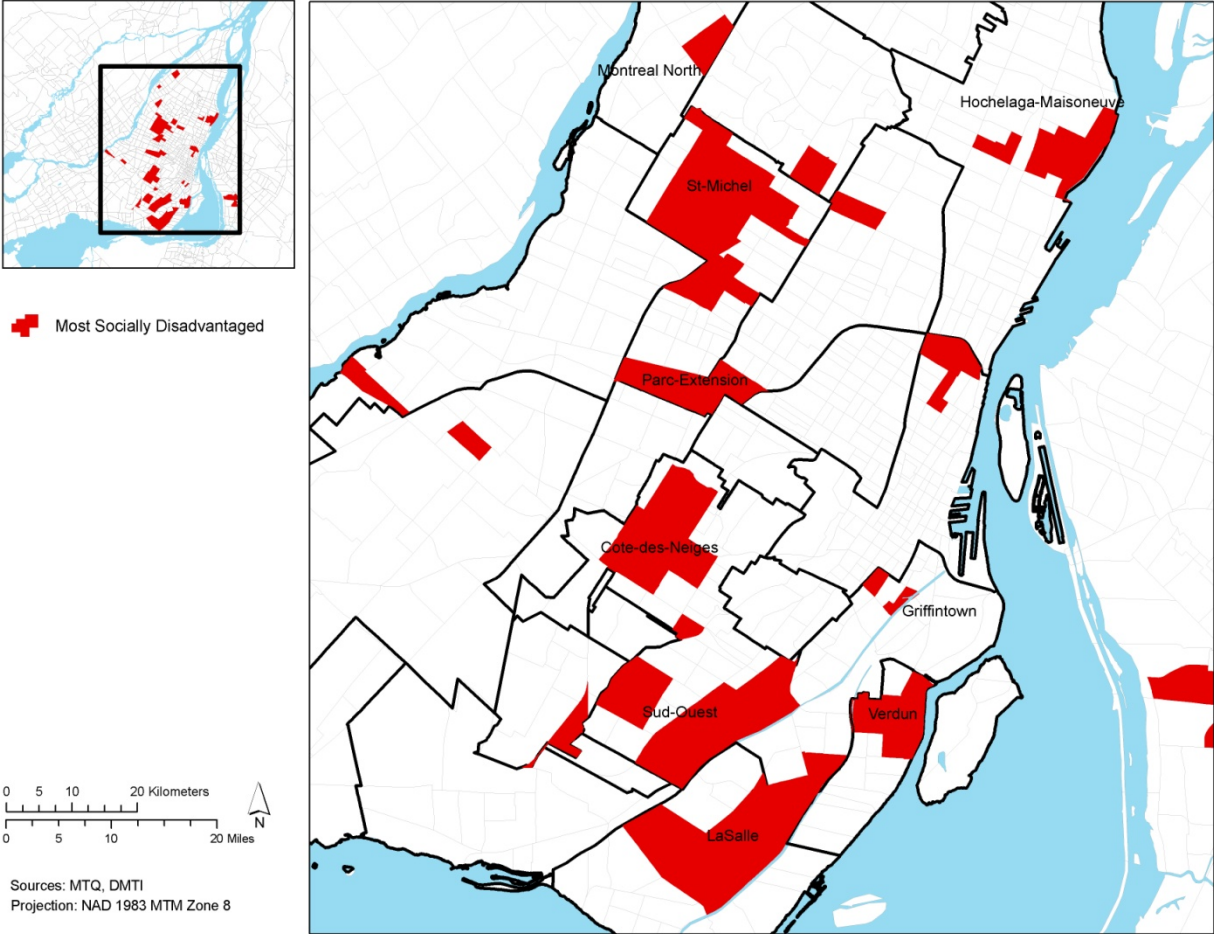

Figure 2: Identification of socially disadvantaged areas

Table 1: Comparison of socially disadvantaged neighborhoods and regional average

Indicator	Socially Disadvantaged	Overall
High school educational attainment	13.0%	10.8%
Visible minority	32.0%	16.7%
Median Household Income (CAD)	32,803	52,392
Transit Modal Split	44.3%	23.2%
All variables are significantly different P<0.001, two sample t test with unequal variance		

Some indicators such as visible minorities and income are quite different; all differ significantly (p<0.001) using a two sample t test with unequal variance. As increases in human interaction, access to destinations and removing barriers to social isolation are considered transit goals then from the perspective of equity, these neighborhoods would be perhaps the most important to prioritize in giving increased choice and accessibility.

Accessibility Impacts of Projects

A first step to understand the effects of the new projects is to observe a map with the changes in accessibility to low skilled jobs. The initial examination of accessibility change maps would seem to suggest that the plan is relatively equitable. In fact, a two sample t-test of the most and least socially disadvantaged neighborhoods shows that the most socially disadvantaged (highest quartile) areas benefit from a higher increase in accessibility to low-wage jobs than the least disadvantaged (lowest quartile). Due to the configuration of Montreal's transit system and the clustering of these low-income neighborhoods relatively close to downtown, this is not entirely surprising. Further analysis shows that certain projects benefit some areas more than others. Figure 3 shows the changes in cumulative accessibility to jobs, the most socially disadvantaged areas are outlined in black. This allows a better visualization of how specific transit improvements help particular areas. In particular, we see how the BRT, metro and commuter rail line have significant effects on Montreal-North. Notably, the airport shuttle has almost no effect on these particular neighborhoods, or, for that matter, on the region as a whole.

Change in Accessibilty

- 0% - 2.6%
- 2.7% - 6.9%
- 7% - 12.1%
- 12.2% - 19%
- 19.1% - 32.8%
- 32.9% - 51.5%
- 51.6% - 73.7%
- Socially Disadvantaged
- Proposed Shuttle
- Propsed BRT
- Proposed Metro
- Proposed Tram
- Proposed Train
- Existing Metro
- Existing Train Lines

0 1.25 2.5 5 Kilometers

0 1.25 2.5 5 Miles
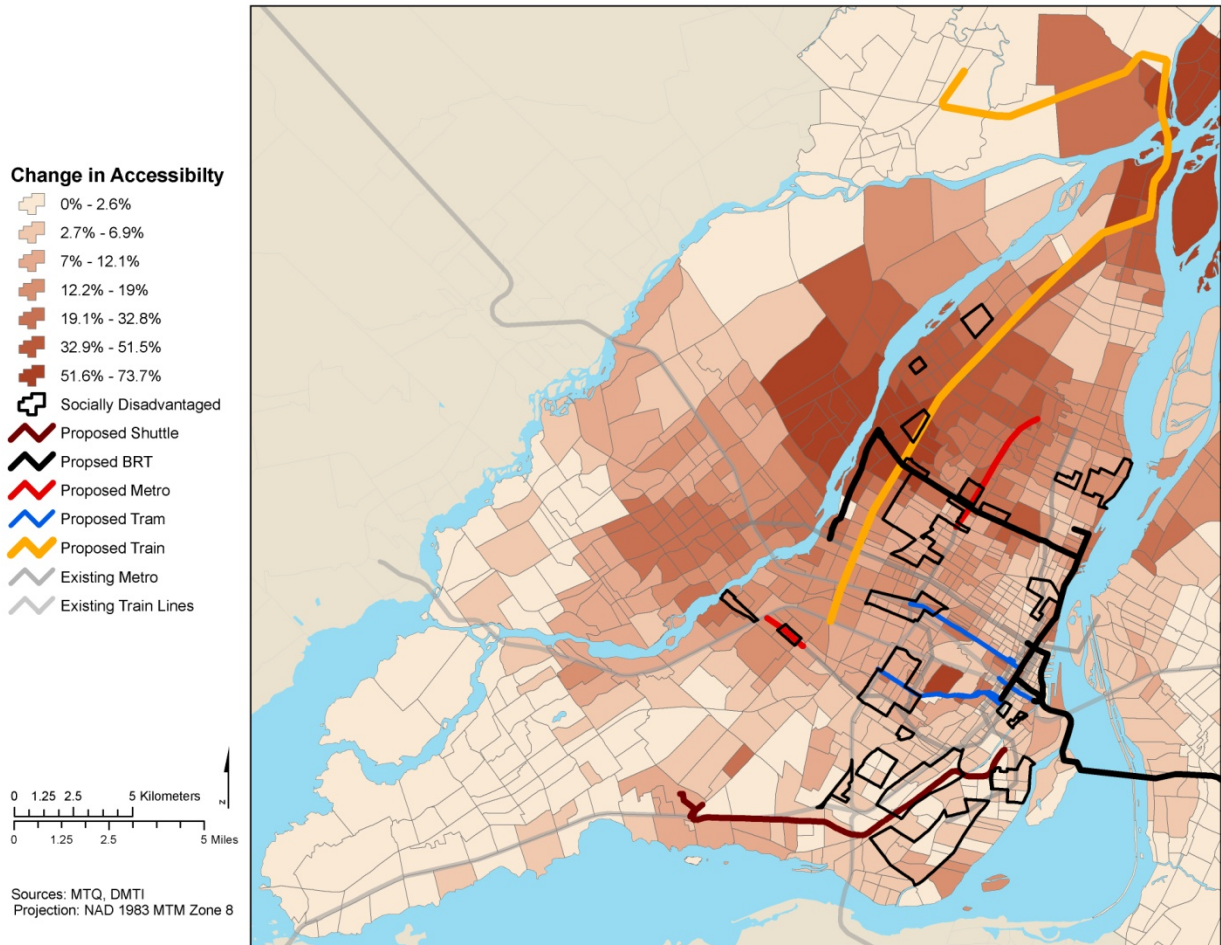
Sources: MTQ, DMTI
Projection: NAD 1983 MTM Zone 8

Figure 3: Changes in accessibility to low-skill jobs with all changes modeled.

Table 2 shows increase in accessibility to all jobs and to low-skilled jobs in particular. In a "best-case scenario", we would hope to see that the percentage increase to low-skilled jobs is higher or equal to the overall increase in access, implying that the transportation plan takes into account the needs of the current residents of the given neighbourhoods. In fact, this is the case in many neighborhoods, Hochelaga-Maisoneuve and Parc-Extension in particular. However, particularly in Montreal-North and St-Michel the overall increase is extremely large, yet the increase to appropriate jobs is much smaller. It is clear that focusing on all jobs could easily misrepresent which jobs are truly accessible and which are not based on skills, knowledge and experience. This focus on residents' current needs is also the principal reason why travel time to current jobs will be the focus of the next section of the study.

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Table 2: Percentage increase in accessibility to jobs (cumulative) overall and for low-skilled jobs requiring only High School education or less.

		ALL	METRO	TRAIN	TRAM	BRT	Shuttle
Cote-des-Neiges	Low skilled jobs	11.1%	4.2%	1.0%	2.9%	1.3%	0.0%
	All jobs	10.9%	3.8%	0.6%	3.0%	1.7%	0.0%
Lasalle	Low skilled jobs	4.4%	0.0%	0.0%	4.2%	0.2%	0.1%
	All jobs	7.7%	0.0%	0.0%	7.1%	0.5%	0.0%
Hochelaga-Maisonneuve	Low skilled jobs	13.7%	10.5%	0.5%	2.1%	5.1%	0.0%
	All jobs	13.2%	7.8%	0.2%	3.7%	3.3%	0.0%
Montreal-North	Low skilled jobs	49.8%	6.4%	45.5%	0.9%	24.1%	0.0%
	All jobs	161.7%	7.9%	124.4%	0.7%	40.3%	0.0%
NDG	Low skilled jobs	3.4%	1.6%	0.0%	0.3%	0.8%	0.2%
	All jobs	3.4%	1.5%	0.0%	0.6%	1.0%	0.1%
Parc-Extension	Low skilled jobs	14.7%	7.4%	7.2%	3.2%	3.1%	0.0%
	All jobs	10.8%	4.5%	4.3%	2.7%	2.3%	0.0%
Saint-Michel	Low skilled jobs	22.8%	8.5%	10.5%	0.7%	12.2%	0.0%
	All jobs	59.0%	7.6%	11.2%	1.3%	36.1%	0.0%
South-West	Low skilled jobs	2.4%	0.3%	0.0%	1.1%	1.1%	0.0%
	All jobs	3.4%	0.1%	0.1%	1.5%	1.7%	0.0%
Verdun	Low skilled jobs	2.9%	0.6%	0.7%	0.3%	1.3%	0.0%
	All jobs	3.1%	0.4%	0.8%	0.8%	1.5%	0.0%
Regional Average	Low skilled jobs	8.9%	2.4%	4.2%	1.0%	2.9%	0.2%
	All jobs	15.0%	2.4%	6.3%	1.4%	4.5%	0.1%

In order to give a fair sense of each neighborhood's improvements in accessibility, standardized (z) scores were calculated before and after the improvements. This allows us to see how each neighborhood fares relative to the regional average and therefore does not "credit" or "penalize" a neighborhood based on its current accessibility. This can be seen in Figure 4 showing the z-score before and after the improvements. The zero line represents the regional average both before and after. Thus, for example, St-Michel is roughly 0.5 and 0.75 above the regional average before and after the changes respectively. What is perhaps most interesting is that no neighborhood crosses the line; the areas seem to either be above or below average. On one hand, Montreal-North, which sees dramatic improvement is still only at roughly the mean point after all changes. On the other hand, neighborhoods such as the South-West, Verdun, or NDG, while not benefitting from certain aspects of the plan are still well above average in their

accessibility to employment. Comparing Table 2 and Figure 4, we can see the contrast in findings based on the terms of measurement used. While Table 2 might imply that certain areas suffer from lack of increased access, Figure 4 gives a slightly more nuanced analysis. That is, from a vertical equity standpoint, it could be argued that Montreal-North "deserves" more accessibility improvements than Parc-Extension or Cote-des-Neiges.
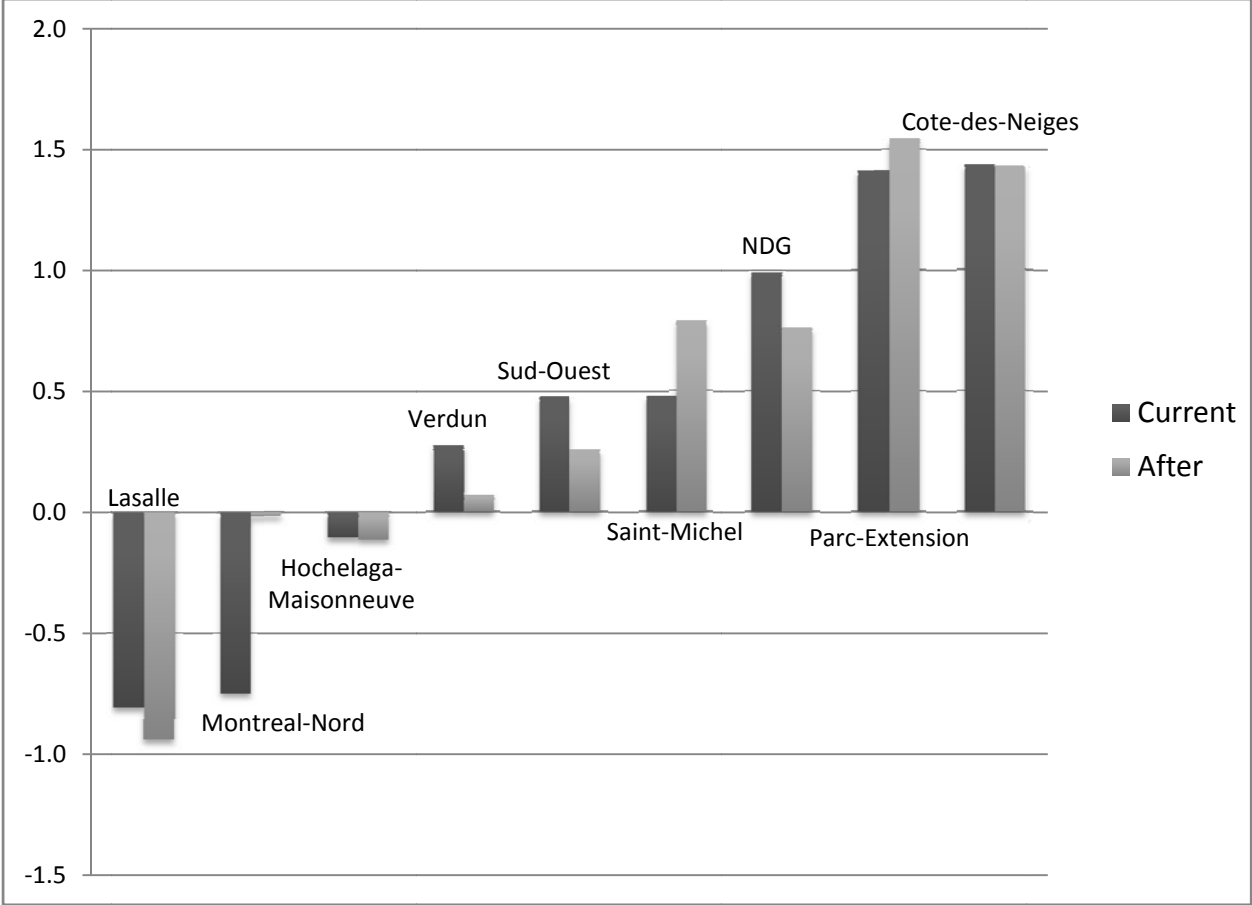

Figure 4: Z-score of low-skill employment accessibility before and after the improvements

Travel Time Impacts of Projects

Accessibility to jobs was seen as not necessarily the only manner to measure equitable outcomes of the plan. Accessibility provided a global picture of the effects of each project. The estimated travel time to each of Montreal's six employment centers was calculated from each of

the most disadvantaged neighborhoods. This allows for two separate analyses, which neighborhoods are most benefitting in terms of faster access to employment centers, and by which project. Obviously, due to the geographic location of each neighborhood, there will be differences among the time savings. Nevertheless, it is interesting to see that Hochelaga-Maisoneuve sees little travel time improvement to any of the major job centers, while Parc-Extension and St-Michel, for example, see marked improvement to all job centers. Another striking finding is that access to Anjou and the CBD seem to be the most improved, all neighborhoods show at least minor improvements to these areas.

Table 3: Reduction in travel time to each of Montreal's job centers (All changes modeled)

	Anjou	CBD	Dorval	Laval	Longueuil	Marché Centrale
Notre-Dame-de-Graces	13.1%	9.2%	0.0%	0.0%	2.7%	0.0%
Cote-des-Neiges South	25.6%	2.2%	0.8%	4.4%	5.6%	4.1%
Lasalle	4.7%	6.6%	0.0%	0.0%	2.6%	0.0%
Hochelaga-Maisonneuve	0.6%	5.8%	0.7%	9.5%	0.0%	12.6%
Montreal-North	7.1%	24.6%	23.9%	31.6%	7.0%	36.6%
Parc-Extension	31.8%	10.6%	2.6%	4.5%	8.7%	2.9%
Saint-Michel	23.3%	12.6%	7.9%	11.4%	11.6%	18.8%
South-West	2.9%	14.0%	0.0%	0.0%	3.6%	0.0%
Verdun	2.8%	13.5%	0.0%	0.0%	4.0%	0.0%
Villeray	30.2%	9.0%	0.0%	0.0%	10.3%	0.0%
Overall in Region	**11.9%**	**3.2%**	**5.5%**	**3.8%**	**1.3%**	**0.2%**

The final stage of the analysis concerns travel-time reductions based on actual home and work locations. For this, we mapped the current home-work commute for all workers in the region. The data is in the form of a residence-employment matrix showing where residents of each census tract work. We were able to estimate travel time savings for individuals as well as analyze and the number of people from a given neighborhood who will benefit from such improvements. The results are summarized in Table 4. If an area is gaining in accessibility to either unsuitable job opportunities or showing decreases in travel time to undesired locations, we could claim that the plan is not taking this neighborhood's needs into account. While we do not want to suggest reverting to focusing on mobility at the expense of accessibility, in the case of

examining the equitable outcomes of the plan, it seems that this travel-time savings is a key factor.

   We see that certain neighbourhoods are better served. The South-west borough, parts of NDG and Griffintown are shown to have the least benefits in terms of travel-time reduction to current jobs. On the other hand, particularly due to the BRT, train and Metro lines, Montreal North, St-Michel and Cote-des-Neiges show very high levels of benefit. This time-savings was examined as average time per person. Montreal-North again stands out as an area with high benefit to current residents. The last column shows estimated travel time savings in person-hours for a one-way commute. Comparing Table 1 and 4, we see that Griffintown, for example does not benefit much in terms of increased accessibility to jobs, however, a large percentage of residents are seeing real, albeit minor, travel time savings on their commute.

Table 4: Improvements in travel time

	Total Workers	% who would see a reduction in their current commute	% who would see a reduction of 5 minutes or more	Avg. time saved (minutes/ person)	Total Hours saved
Cote-des-Neiges	18120	51.1%	7.1%	1.3	37.6
Griffintown	1265	29.6%	0.0%	0.2	0.8
Lasalle	9795	13.2%	1.1%	0.3	4.1
Hochelaga-Maisonneuve	4090	33.7%	3.3%	0.8	7.9
Montreal-North	2135	66.3%	52.0%	6.7	25.8
NDG	14575	9.0%	1.6%	0.2	8.7
Parc-Extension	9685	41.7%	15.0%	1.6	25.9
Saint-Laurent	1420	96.8%	8.8%	2.7	6.6
Saint-Michel	9195	50.4%	28.2%	2.9	51.2
South-West	3415	20.9%	1.6%	0.4	1.7
Verdun	7610	22.5%	1.9%	0.5	6.0
Villeray	5145	30.7%	10.6%	1.4	15.4
Overall Region	1031150	34.5%	11.2%	0.7	2776.8

   Figure 5 shows that those near the train, metro and BRT benefit the most in terms of travel time to their current jobs. Surprisingly, the airport shuttle seems to do little to improve commuting time. This figure is based on the assumption that residents will keep their current jobs. The map seems to show a east/west divide with those in the western part of the island

seeing much less direct benefits from the plan. However, some may argue that this actually shows the equitable aspect of the plan. The vast majority of the "low-change" areas to the west of the island are wealthy suburban-style developments, while most of the areas more affected are more likely to be poor, with more recent immigrants and higher rates of unemployment.
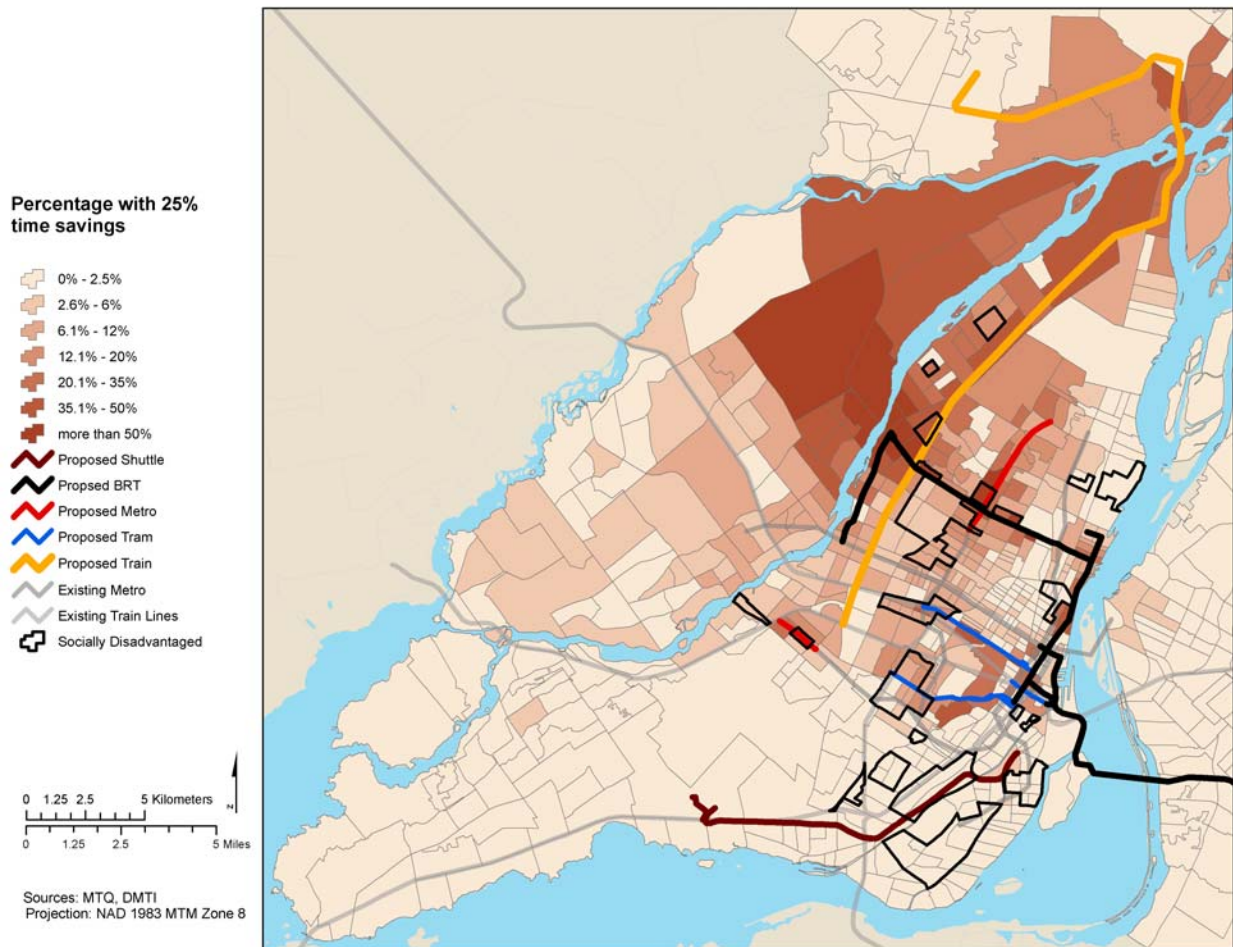

Figure 5: Percentage of residents who would see a 25% travel time reduction or more on their current commute

CONCLUSION

This paper explores several issues related to accessibility and equity and adds to the burgeoning debate on this topic. Among other findings, it would suggest the importance of scale,

definition and appropriateness of measurement. From a regional standpoint, the plan seems to succeed. Many people who presently lack good accessibility and connections to employment centers will see increased benefits. Due to the geographic location of many disadvantaged neighborhoods, and the focus of most new transit infrastructure near the CBD, the plan does provide quite well to many poorer neighborhoods. However, on a micro-scale we see that certain neighbourhoods fare much better than others.

The measures of accessibility generated in here allow for a long term vision. Having access to more jobs within the labor market increases the number of opportunities available to the disadvantaged population at the long term. It also has a short term impact on non-work travel. Higher access to more jobs is a reflection of higher access to services, which can lead to shorter travel times to access the basic needs such as shopping. On the other hand, the travel time analysis shows the short term impact on individual mobility, since each person is only concerned how to access his existing job and to what extent the new plan will help him in doing so. Meanwhile the analysis of travel time to job centers concentrates on the long term aspect and flexibility that the plan can offer to the socially disadvantaged population in term of job search in the future.

This paper set out to answer a relatively straightforward question; how well do currently socially isolated and disadvantaged neighbourhoods benefit from transit improvements and how is this quantified as time-savings to job locations. As sustainability goals continue to grow in importance for transit providers, it is important that easier-to-measure goals such as ridership and environmental impact do not become prioritized at the expense of considerations of equity. It is not our intention, however to take the discussion completely away from these important economic or environmental considerations. For example, the proposed commuter train has the potential to be both an economic force in a relatively undeveloped region as well as being a possible solution to limiting GHG emissions for both current and future residents. In fact, this could be the most beneficial project from an environmental standpoint, if the potential time savings translate into mode shift. Interestingly, we also observe what might be termed a "spillover effect" of the commuter rail. While the rail line has been primarily designed to serve residents at the periphery, the planned route and station placement may very well aid many in

low-income neighborhoods. A focus on suburban mode shift is not necessarily misguided, and only becomes a concern if it leads to neglect of transit-captive riders elsewhere. On the other hand, it does seem clear that the BRT lines have the possibility to both connect workers to potential jobs as well as get them to current jobs for possibly a fraction of the cost of rail improvements. However, it is beyond the scope of this paper to do a full cost/benefit analysis which weights equity issues in some manner.

Regional transit agencies interested in providing service in an equitable manner would be encouraged to understand important characteristics of underserved populations by asking three questions. Firstly, who and where are the under-served populations located? Secondly, where are their places of employment? Lastly, how can they better be served? Answering these questions might allow for the most appropriate transit solution for the needs of these populations. Faster connections, more reliable service, new areas of access, or entirely new routes might be the response. Relatively straight-forward GIS techniques can aid greatly in answering these questions at both the regional and personal scales.

This research is not without limitations. Further research might utilize census micro-data for a more accurate exploration of who lives in certain neighbourhoods. The aggregate approach misses socially disadvantaged individuals living in other neighborhoods. Accessibility *to* transit was not examined thoroughly; neighbourhood-scale walkability factors play an important role in the attractiveness and comfort of using transit. Also, a fairly narrow view of the role of transit – connecting workers to jobs – is utilized; however, the approach is backed up theoretically and by previous research. Modeling transit presents its own unique challenges. Different individuals might have dramatically differing attitudes and preferences towards waiting times, frequencies of stops, number of transfers, as well as type of transit mode. So, for some, a minute on a train may not equal one minute on a bus. This, however, is a subtlety that we were not able to bring into the analysis. Lastly, it could be argued that focusing only on low-skill jobs is problematic. Nevertheless we feel that focusing on current needs is more important than speculating on future trends, while we certainly would like to see these residents find and secure well-paid employment.

This paper leaves many questions unanswered. How decision-makers will adapt to changing goals of transit remains to be seen. Our results highlight the importance of multi-criteria evaluation as the findings would suggest that potential environmental benefits of some projects are not necessarily aligned with issues of equity or need. It is hoped that policy-makers bear in mind these subtleties when prioritizing among projects. The simple approach outlined here shows how accessibility measures can be utilized to indicate the extent to which transit projects are equitably distributed among those with the most need. While the changes in travel time highlights the personal benefits that individuals will gain from the implementation of the new projects.

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