IS COMPLEXITY BETTER?

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Assessing accessibility measures that account for daily fluctuations in transit and jobs availability

CONTEXT

Accessibility to jobs by transit is increasingly incorporated into transportation and land-use planning objectives, as it is proven to be a relevant indicator for assessing **land-use and transportation systems performance.**

In recent years, a plethora of accessibility measures have been developed, namely with regard to temporal fluctuations. **Choosing the appropriate measure** is increasingly challenging for engineers, planners and policy-makers

This methodological study explores whether **time-sensitive measurements** of accessibility to jobs by transit throughout the day provide a more appropriate measure of accessibility, through a comparative analysis of three accessibility measures.

ACCESSIBILITY AND TIME

Accessibility, defined as the potential to reach desired destinations, depends on the **transportation infrastructure** and the **location of opportunities** (in our case, jobs).

Recent research has develed measures that are sensitive to temporal constraints. These include:

- Bus, subway and streetcar schedule (Transit service)
- Working hours (Jobs availability)

METHODS

1 Accessibility measures

Using the Greater Toronto and Hamilton Region (GTHA), three measures of accessibility, two of which are time-sensitive, are generated for five time periods at the census tract level.

Overview of the Accessibility Measures

Type of measure	Transit service	Jobs availability
Constant	Constant	Constant
Static	*Variable*	Constant
Dynamic	*Variable*	*Variable*

The measures are generated based on cumulative opportuntities, counting the number of jobs that are within a specified time threshold (45 minutes) by public transport.

$$A_i = \sum_{j=1}^{n} O_j f(C_{ij}) \qquad f(C_{ij}) = \begin{cases} 1 \text{ if } C_{ij} \leq t \\ 0 \text{ if } C_{ij} > t \end{cases}$$

A_i : Accessibility at census tract i
O_j : Number of jobs at destinations j
C_{ij} : Travel time from i to j
t : time threshold (45 minutes)
n : number of census tracts

2 Regression analyses

Regression models are generated using the same dependent and independent variables, except for the accessibility measure. Measure accuracy is assessed based on the models fit (R2), working with the assumption that more accurate accessibility measures should result in better model fit.

- Dependent variable: Transit share at specified time period
- Independent variables: Relative accessibility measure (and control variables)
- Outcome: Model fit (adjusted R2)

Regression Result for Transit Share at 8 am Using Dynamic Accessibility Measure

Variable	Coefficients
Transit frequency	0.000096
In urban core	0.16***
In inner suburbs	0.16***
1 km to subway station	0.028*
1 km to GO station	0.0058
Distance to highway on-ramp	-0.00062
Social indicator decile	0.011***
Mean distance travelled	0.0014*
Population density	0.0018**
Accessibility to available jobs at 8 am	0.060***
Constant	0.030**
R^2 (adjusted)	0.7861

*p<0.05 **p<0.01 ***p<0.001

RESULTS AND ANALYSIS

1 Similar performance of the regression models

Findings show that all three measures behaved similarly in the three regression models. The sets of models using more detailed measures of accessibility (static and dynamic) do not provide better model fits than models using constant measures.

Althgouh static and dynamic measures are expected to provide better model fits, a smaller amount of data, due do **data stratification**, contributes to decreasing the performance of the models.

Performance of the Models (R2-Adjusted Reported)

Accessibility parameter	6am	7am	8am	9am to 12pm	12pm to 5am
None	0.5042	0.6817	0.7625	0.6338	0.6707
Constant	0.5259*	0.7070*	0.7854**	0.6432	0.6831*
Static	0.5258	0.7068	0.7854**	0.6441*	0.6821
Dynamic	0.5212**	0.7052**	0.7861*	0.6424**	0.6797**

*Highest R^2
**Lowest R^2 (excluding the models with no accessibility parameter)

2 Relative accessibility is constant accross time

Relative accessibility at 8 am, which reflects the constant measure, is highly correlated with relative accessibility at other time periods both for static and dynamic measures.

Correlation Coefficient between Accessibility Measured at Each Time Period and Accessibility at 8 am

Time period	Static	Dynamic
6 am	0.97	0.95
7 am	0.99	0.99
8 am	1	1
9 am to 12pm	0.98	0.98
12 pm to 5 am	0.98	0.95

*Note that all correlations are statistically significant (p<0.05)

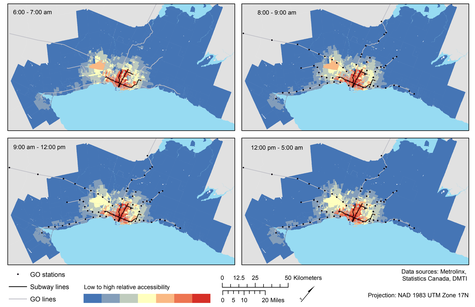
3 Static and dynamic measures are highly correlated

Accessibility at 8 am, which reflects the constant measure, is highly correlated with accessibility at other time periods both for static and dynamic measures.

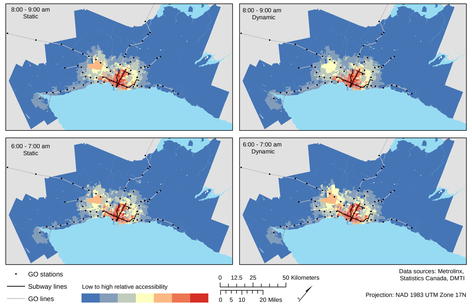
Correlation Results between Static and Dynamic Measures for All Time Periods

Time period	Coefficient
6 am	0.997
7 am	0.999
8 am	0.998
9 am to 12pm	0.995
12 pm to 5 am	0.986

*Note that all correlations are statistically significant (p<0.05)



Relative accessibility to available jobs in the GTHA (static)



Relative accessibility to jobs in the GTHA (static and dynamic)

MEASURES USABILITY

The results show that the constant measure at 8 am is representative of the relative accessibility (static or dynamic) over the course of the day in the GTHA.

Performance of the Measures Based on Usability Criteria

	Constant	Static	Dynamic
Theoretical soundness	+	++	+++
Data requirements	+++	++	+
Communicability	+++	++	+
Empirical soundness	++	++	++

All criteria considered, the constant measure is the **most usable** as it is easily communicable, empirically sound and does not require data stratification.

CONCLUSION

The results suggest that the **constant measure** based on cumulative opportunities, most often used by planners and engineers is the **most appropriate and meaningful** to assess relative accessibility at the regional scale.

This work highlights the need to address the **gap** between accessibility **research** and its **application** to planning, by taking into account the usability of the measure.

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