Long-term travel demand and land value developments in the GTHA

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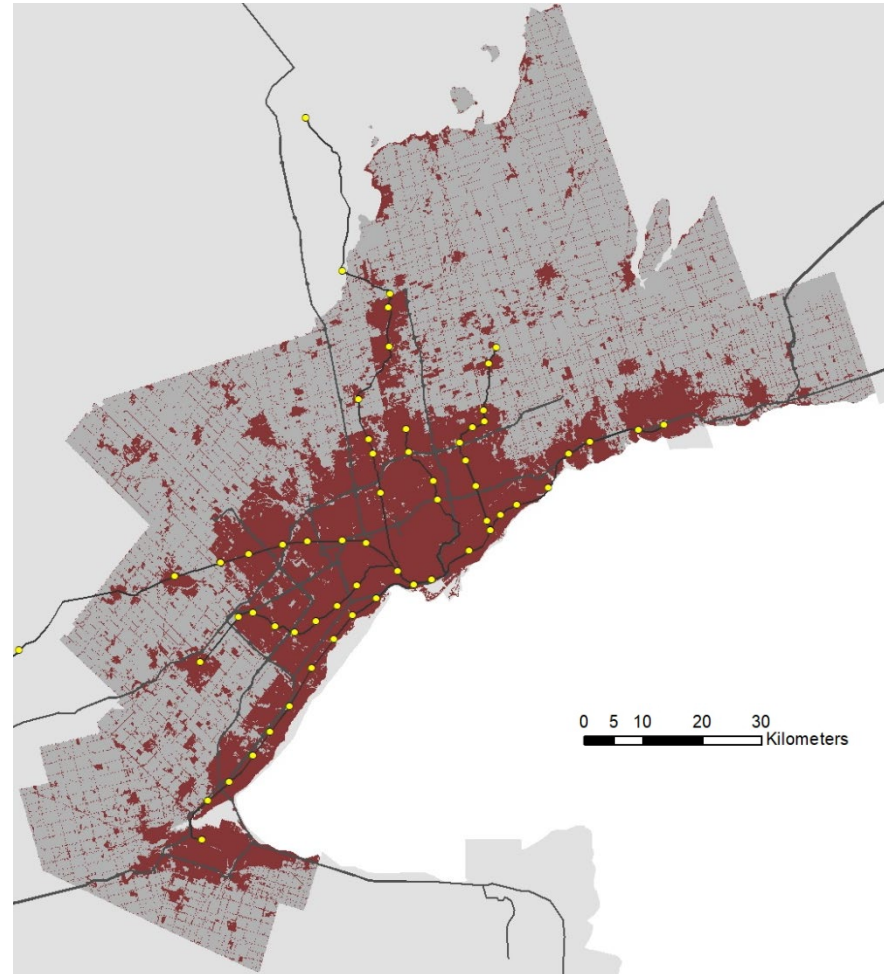Transportation Research Institute

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Research goals

- Understand the trend of travel demand and land value developments in Greater Toronto-Hamilton Area (GTHA)

- Identify their determinants over time and across space

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- **The Greater Toronto-Hamilton Area (GTHA)**
- Area: 8,262 km^2
- Population ≈ 7.1 M
- Density: 922/km^2

Travel demand = f(accessibility, socio-demographics, urban form)

Data

- **Spatial unit of analysis:** approx. 1700 traffic analysis zones (TAZ)
- **Time frame:** 1986 to 2016 with five year intervals

- **Travel demand + socio-economic variables**

Transportation Tomorrow survey (TTS)

Data Management group, 1986-2016, approx. 5% of GTHA households

- **Socio-economic variables**

Census + TTS

- **Transportation infrastructure**

EMME Transportation networks

Travel Modelling Group

Investigated variables

Accessibility in the GTHA, travel times

Travel time matrices:

- by transit and road
- at the TAZ level (approx. 1700)
- for ten time points of five year intervals from 1971 to 2016, using EMME networks

→ approx. 3 million ODs per mode per time point

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Accessibility in the GTHA, travel times
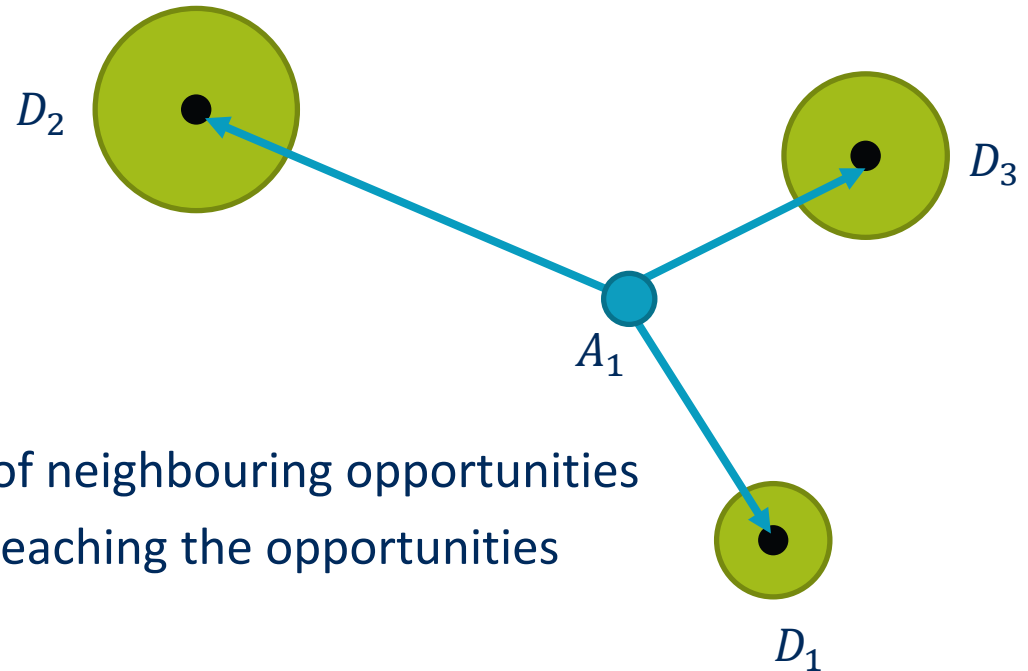
Travel time matrices:

Transit

- GO train + subway + streetcar + bus (GO and normal)
- Transit time = walk time (access/egress) + wait time (average headway) + in transit vehicle time

Road

- Free flow travel times
- Travel times with congestion

Potential accessibility
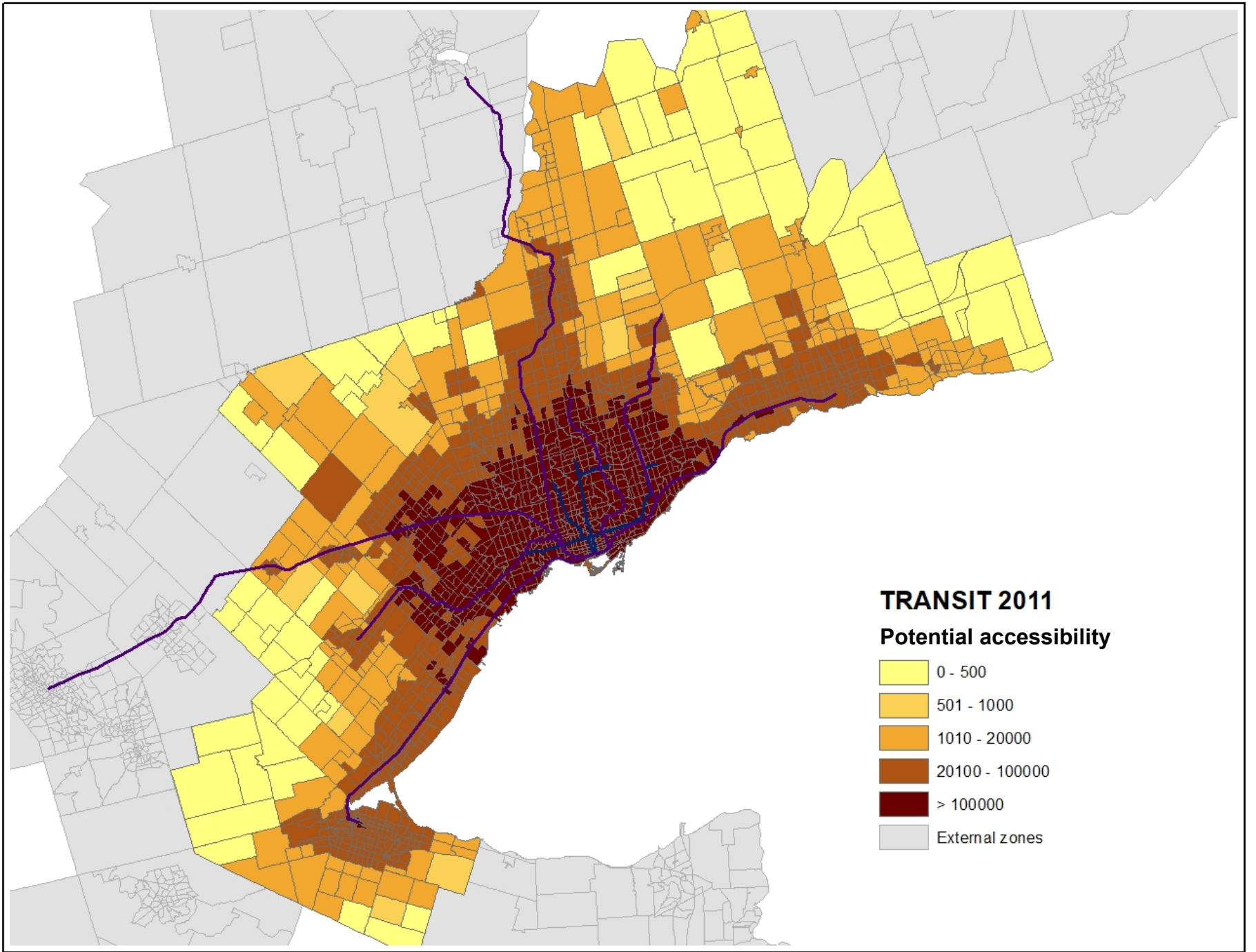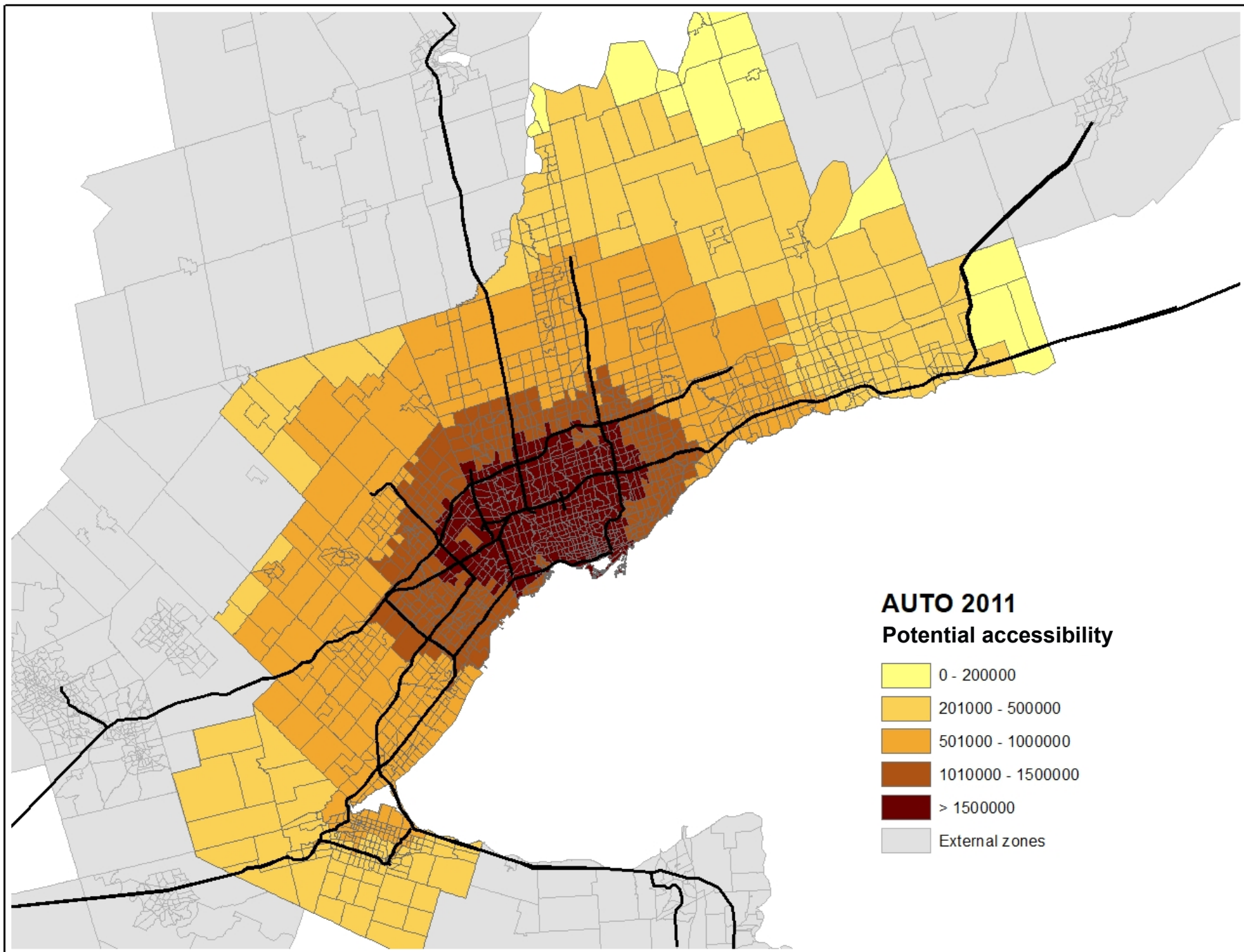

- Increases with the amount of neighbouring opportunities
- Decreases with the cost of reaching the opportunities

$$A_i = \sum_{j=1}^{n} D_j e^{-\beta c_{ij}}$$

D_j = population of zone j

C_{ij} = travel time between i and j

TRANSIT 2011

Potential accessibility

- 0 - 500
- 501 - 1000
- 1010 - 20000
- 20100 - 100000
- \> 100000
- External zones

AUTO 2011
Potential accessibility

- 0 - 200000
- 201000 - 500000
- 501000 - 1000000
- 1010000 - 1500000
- > 1500000
- External zones

VKT calculation

For *TAZ i* at time *t* :

$$VKT_i^t = \sum_{j=1}^{n} G_{i,j}^t * D_{i,j}^t$$

- $G_{i,j}^t$: no. of 24-hour vehicle trips generated from zone i to zone j
- $D_{i,j}^t$: Equilibrium travel distances between origin and destination zones
- Intra-zonal distances included for VKT
- PKT similarly calculated using existing transit demand and supply at each time point

Trip density as a proxy for degree of urbanity

- Mean trip density 1986-2016 in sextiles

Legend

- rural
- ▢
- ▢
- ▢
- ▢
- very urban

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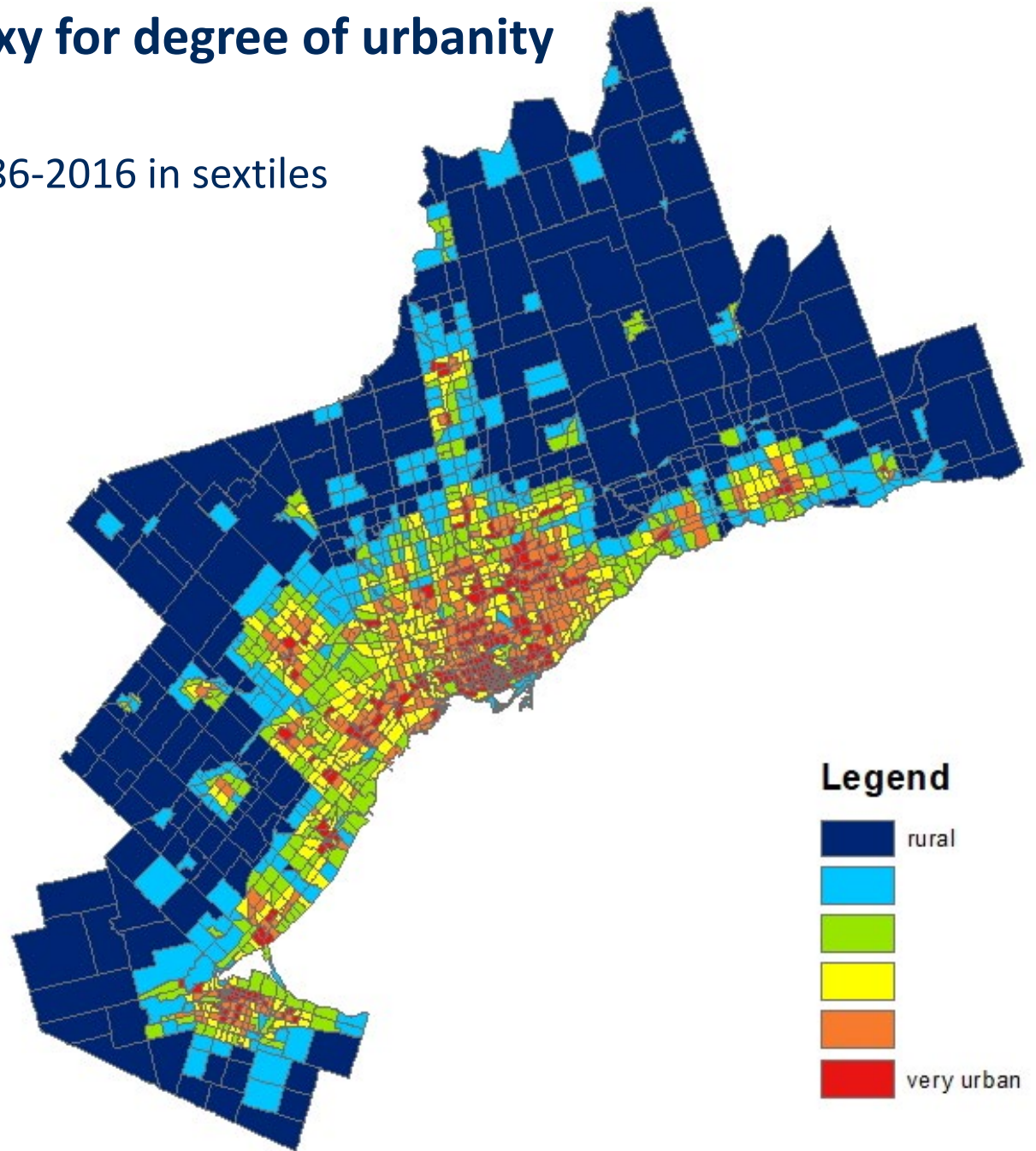
List of investigated variables: Accessibility indicators

(e.g. gravity-based accessibility to population and jobs, distance to transit infrastructure, road and transit density)

Variable	Source
a. Accessibility indicators	
Travel time by car	Calculated
Travel time by transit	Calculated
Relative population access by car	Calculated
Relative population access by transit	Calculated
Relative job access by car	Calculated
Relative job access by transit	Calculated
Road line density	Calculated
Transit line density	Calculated
Straight-line distance to nearest transit station (Km.)	Calculated
Network distance to nearest transit station (Km.)	Calculated

List of investigated variables: socio-demographic indicators
(household characteristics, income, no. of workers/vehicles, type/workplace of workers, education, primary mode of travel)

b. Socio-demographic-economic indicators

Population density	Census
Employed labourforce density	Census
Unemployment rate	Census
Jobs density	TTS
Average household size	Census
Average household income ($)	Census
Median household income ($)	Census
Total cars in a zone (Nos.)	TTS
Households with no vehicle (%)	TTS and Census (dwellings)
Households with 1 vehicle (%)	TTS and Census (dwellings)
Households with 2 or more vehicles (%)	TTS and Census (dwellings)
Average vehicle per household	TTS
Educated population (%)	Census
Population with secondary school certificate or diploma (%)	Census
Population with post-secondary certificate or diploma (%)	Census
Population with post-secondary degree (%)	Census
Workers in industry - Agriculture, forestry, fishing and hunting (%)	Census
Workers in industry - Mining, quarrying, and oil and gas extraction (%)	Census
Workers in industry - Manufacturing (%)	Census
Workers in industry - Construction (%)	Census
Workers in industry - Transportation, warehousing & utilities (%)	Census
Workers in industry - Wholesale and retail trade (%)	Census
Workers in industry - Finance, insurance, real estate, rental and leasing (%)	Census
Workers in industry - Commercial, business, social services (%)	Census
Workers in industry - Government services (%)	Census
Workers in industry - Other services (%)	Census
Workers in blue-collar jobs (%)	Census
Workers in white-collar jobs (%)	Census

b. Socio-demographic-economic indicators

Workers with usual place of work (%)	Census
Workers with no fixed place of work (%)	Census
Households with no full-time worker (%)	TTS
Households with 1 full-time worker (%)	TTS
Households with 2 or more full-time workers (%)	TTS
Households with no student (%)	TTS
Households with 1 or more students (%)	TTS
Households with nobody working from home (%)	TTS
Households with 1 or more people working from home (%)	TTS
Primary travel mode of transit trips - local transit excluding GO rail (%)	TTS
Primary travel mode of transit trips - GO rail only (%)	TTS
Primary travel mode of transit trips - Joint GO rail and local transit (%)	TTS

List of investigated variables: built environment indicators

(e.g. dwelling type/costs and tenure, amount of built-up area, distance to CBD)

c. Built environment indicators

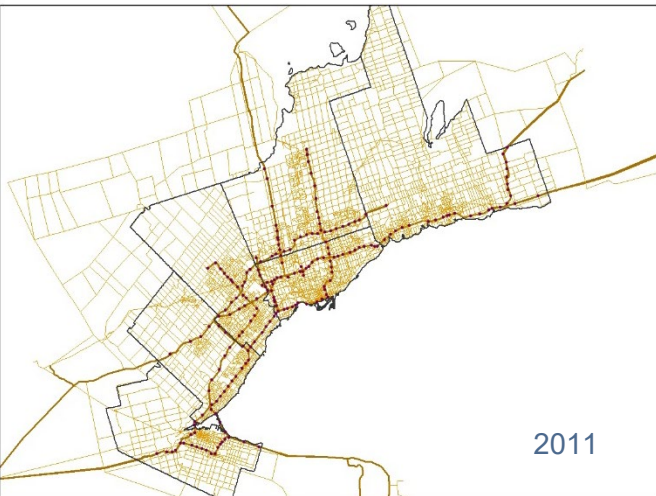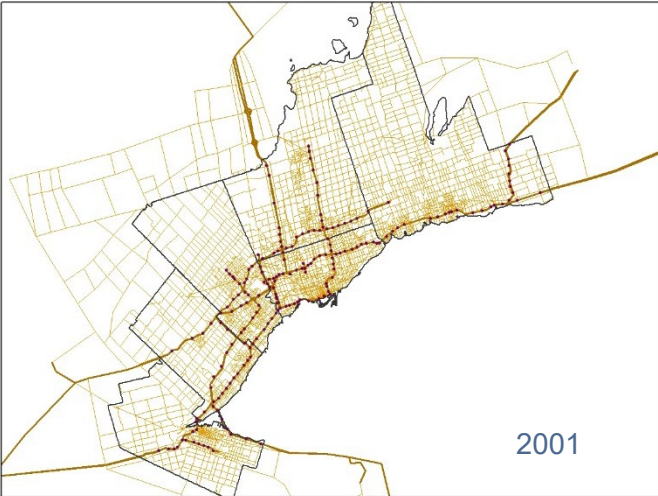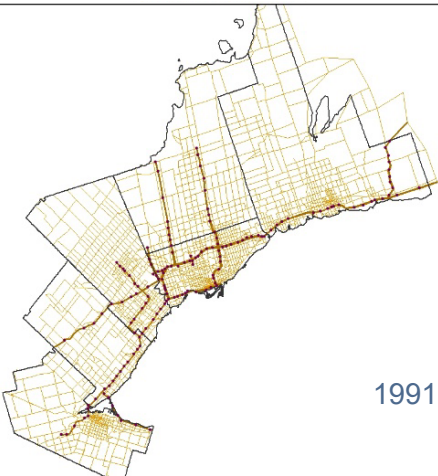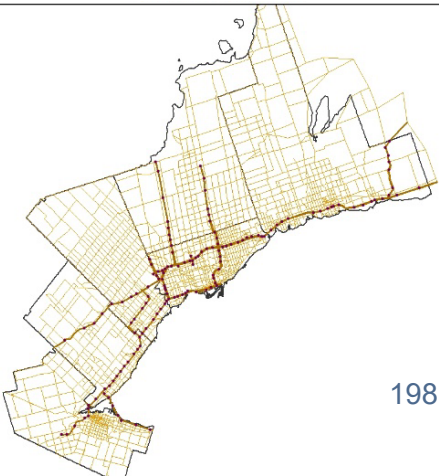|	
Trip density	Calculated
Total transit trips (Nos.)	TTS
Single-attached dwellings (%)	Census
Single-dettached dwellings (%)	Census
Apartments - dwellings with 5 or more stories (%)	Census
Built-up area (Sq.Km.)	CLUMP, AAFC land use
Zone's built-up area fraction	Calculated
Population density of built-up area	Calculated
Rented dwellings (%)	Census
Owned dwellings (%)	Census
Total dwellings (%)	Census
Dwelling density	Calculated
Average monthly shelter costs for rented dwellings ($)	Census
Average monthly shelter costs for owned dwellings ($)	Census
Average value of dwelling ($)	Census
Distance of zone from the CBD (Km.)	Calculated

Overview of trends

GTHA commuter rail and subway 1971 - 2011

1971

1981

1991

2001
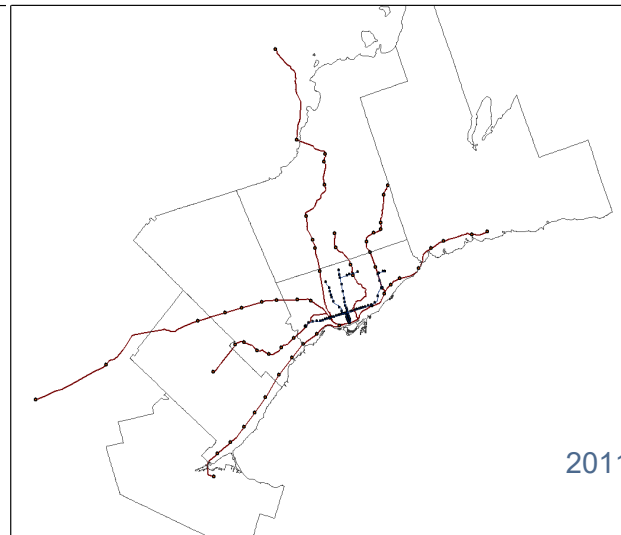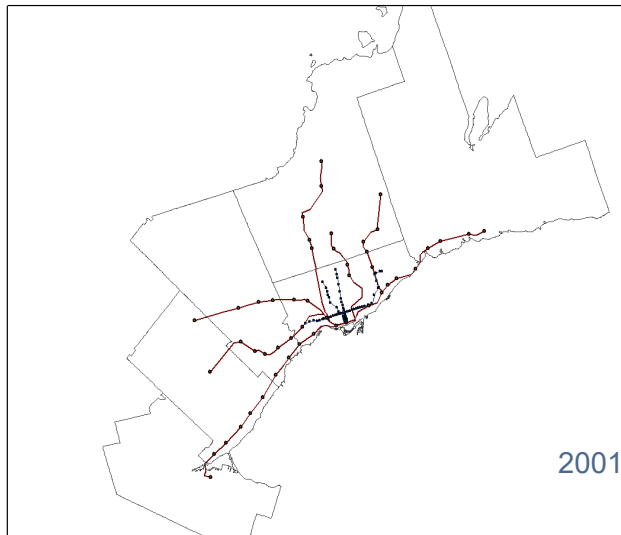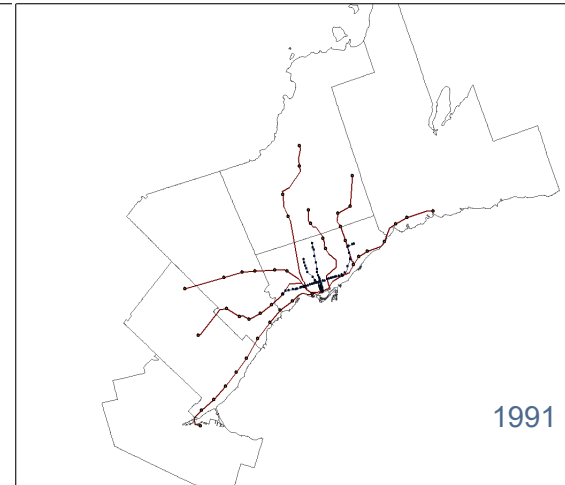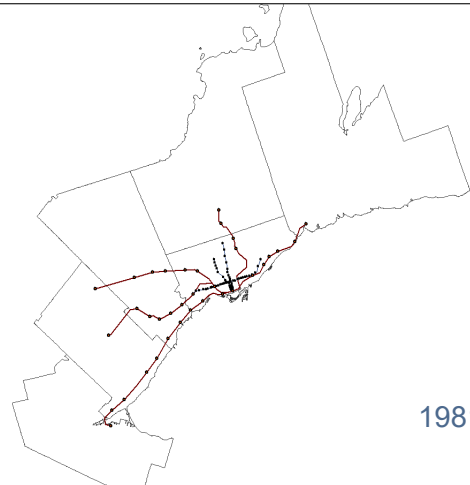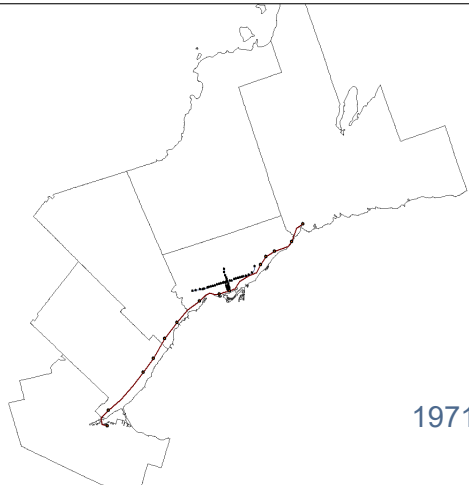
2011

GTHA Road Network 1971 - 2011

1971

1981

1991

2001

2011

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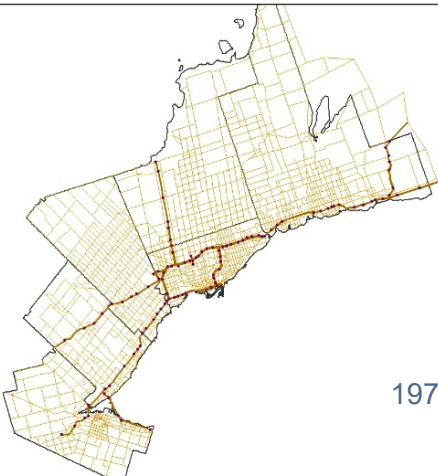
Transit and highway network lengths [km]

Transit and highway network lengths [km]

1966   1971   1976

1981   1986   1991

2001   2011   2016

Toronto   Hamilton

0   25   50   100 Kms.

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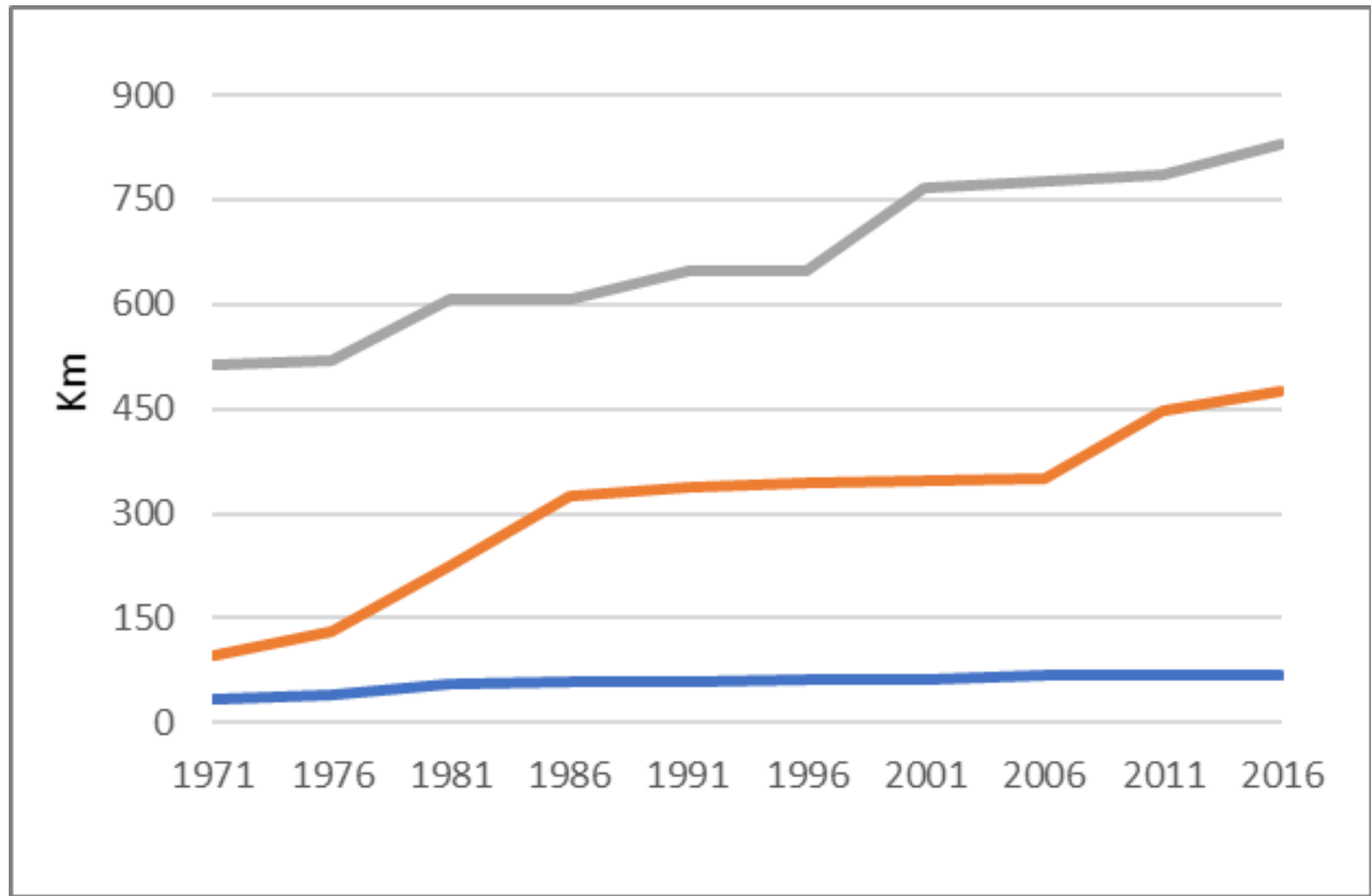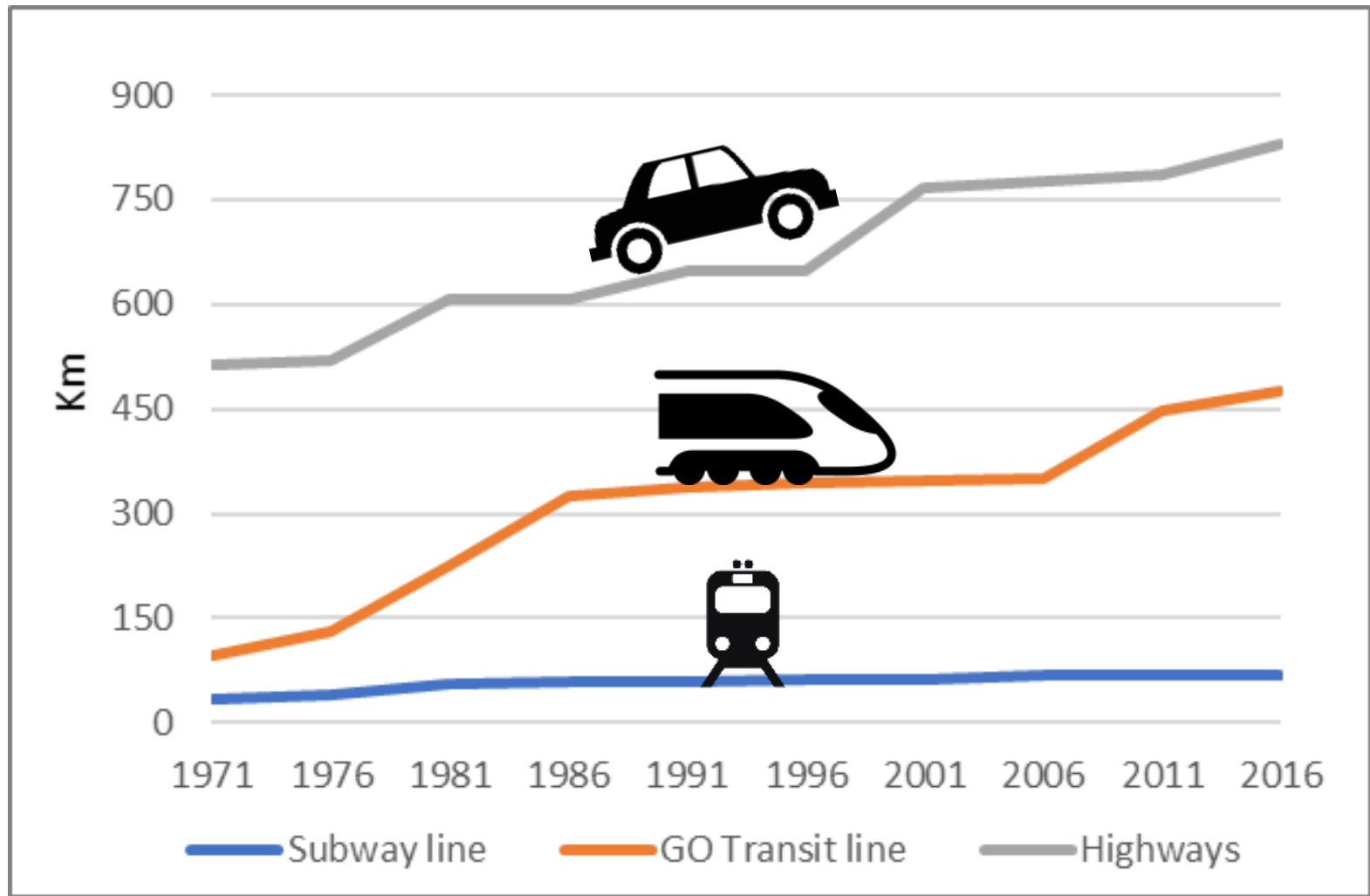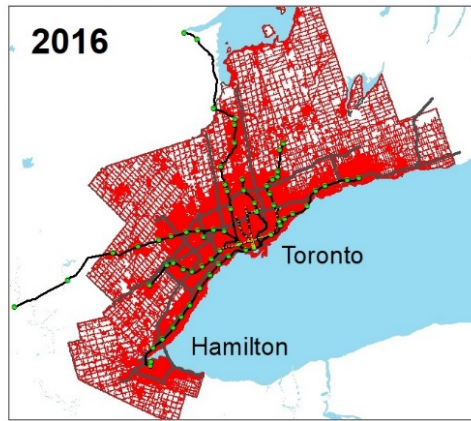
Population and transportation infrastructure growth rates in a glance
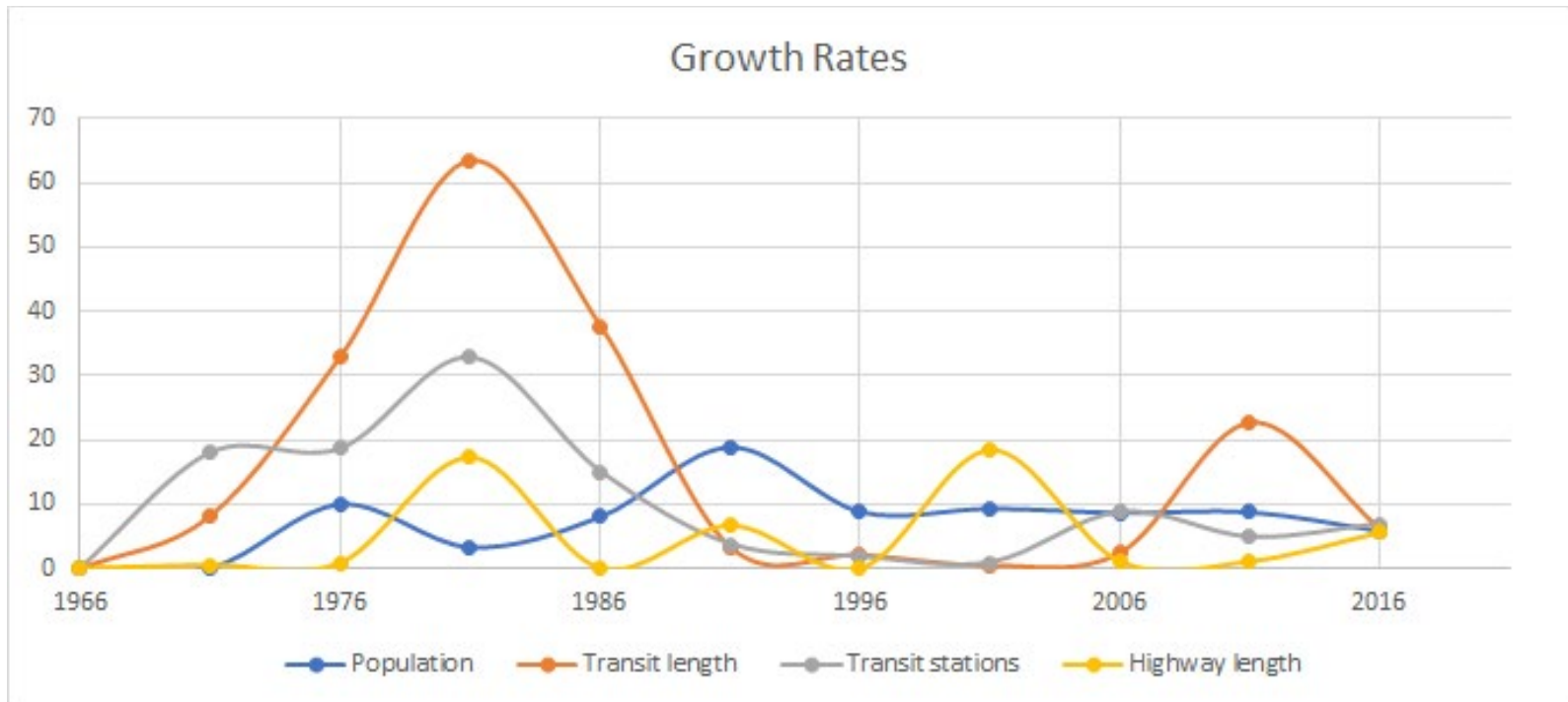
Potential mean travel times by auto and transit
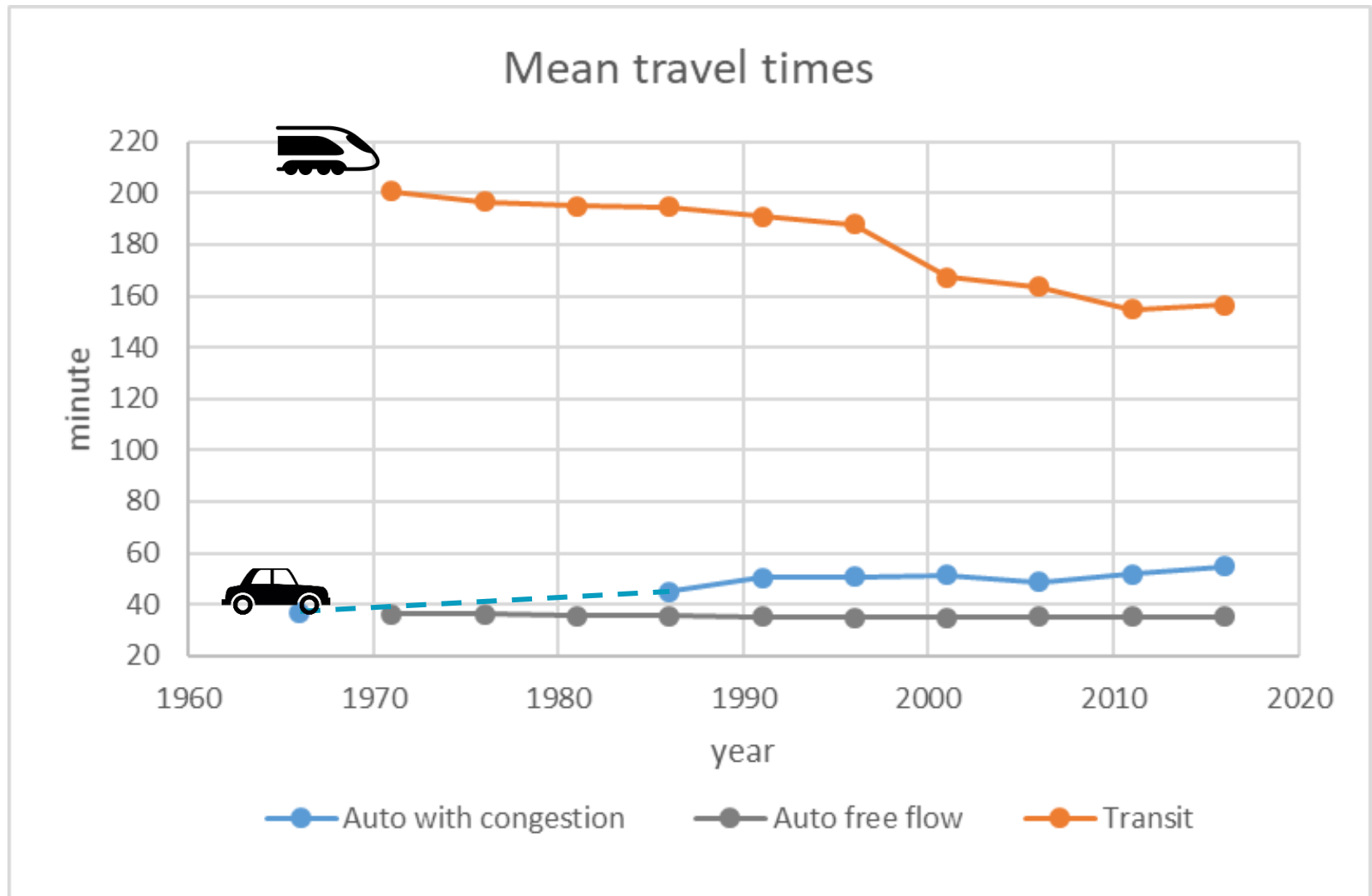
Total daily generated VKT and PKT

- VKT growth = 111%
- PKT growth = 130%

Total generated VKT & PKT
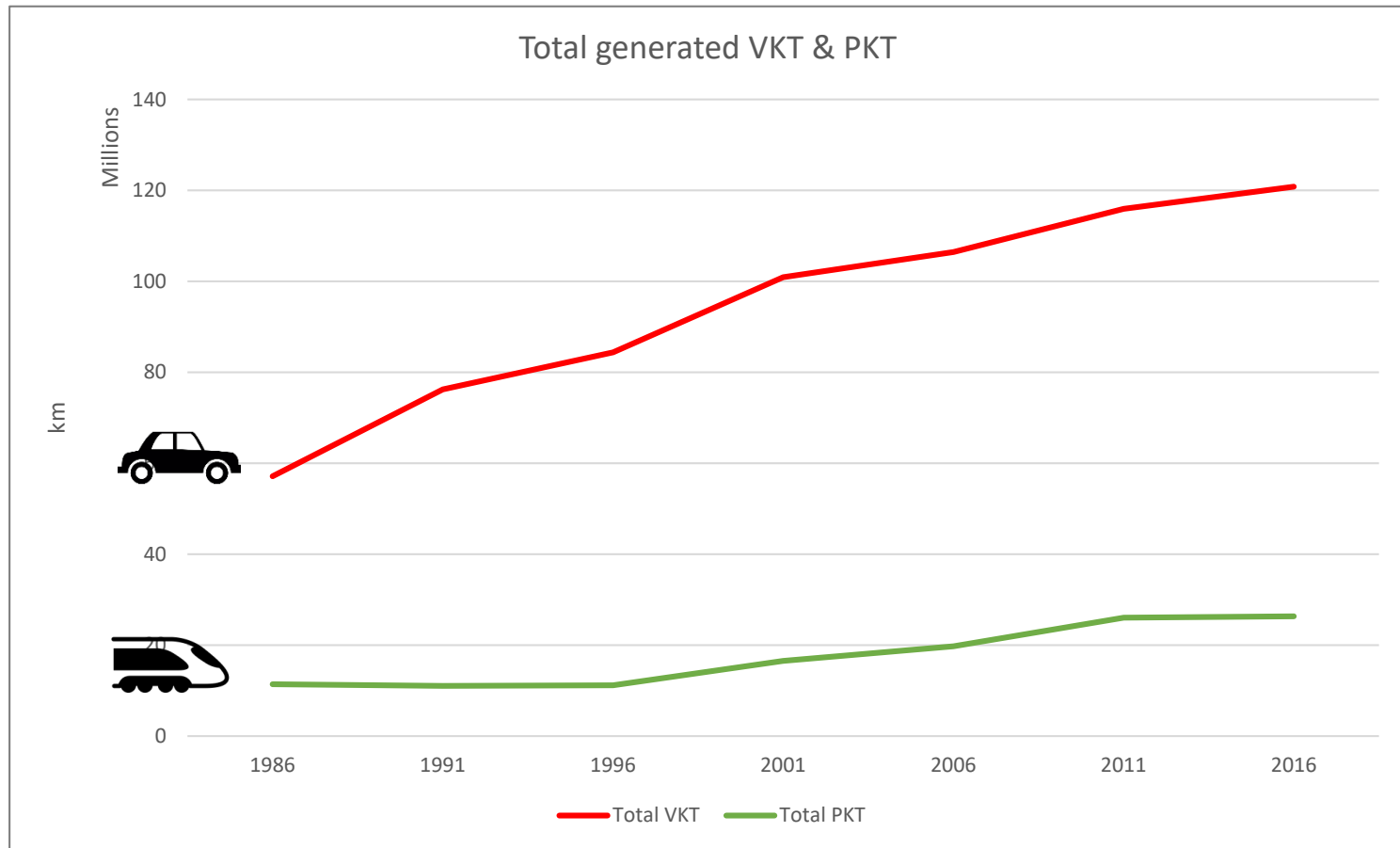
Total generated VKT by degree of urbanity

- Highest VKT growth in the rural (but not very rural) areas

Total generated vkt by degree of urbanity

Legend:
- very urban
- (orange)
- (yellow)
- (green)
- (light blue)
- very rural
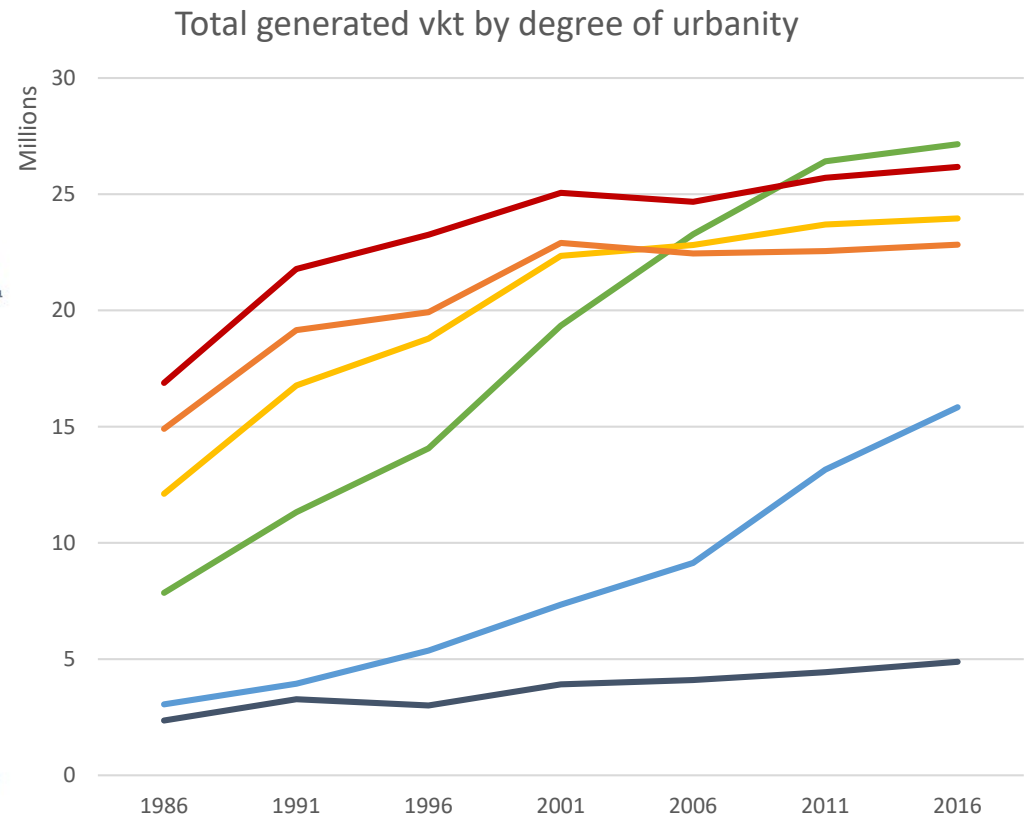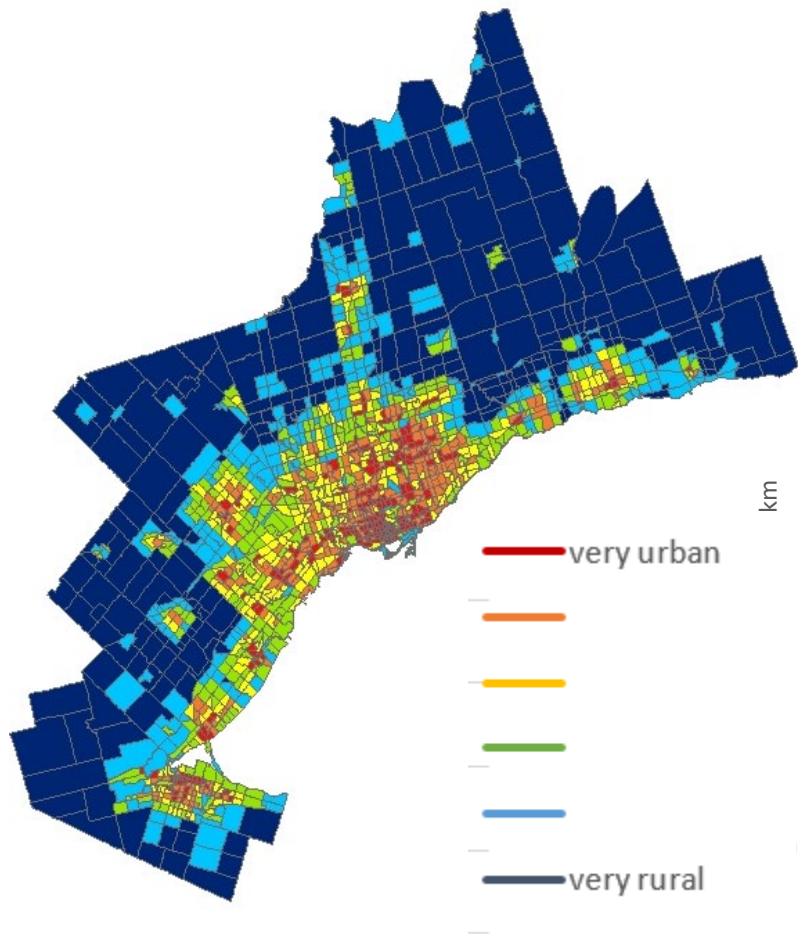
Total generated PKT by degree of urbanity

■ Highest PKT generation and growth in the very urban areas

Total generated pkt by degree of urbanity

Legend:
- very urban (red)
- (orange)
- (yellow)
- (green)
- (light blue)
- very rural (dark grey)

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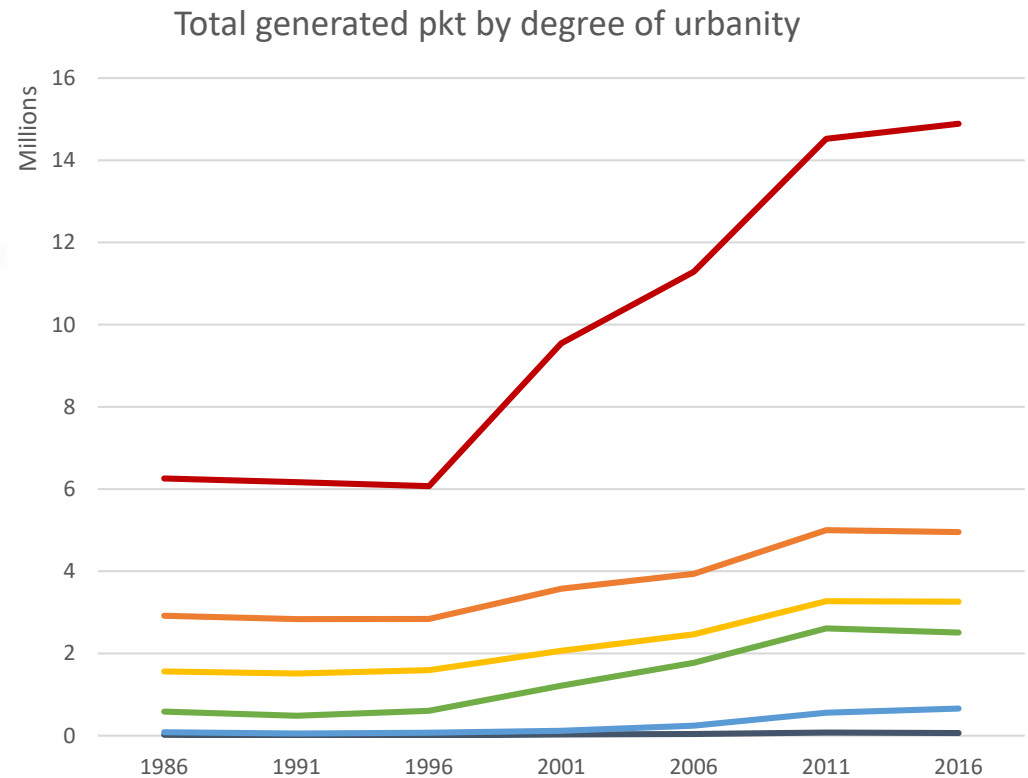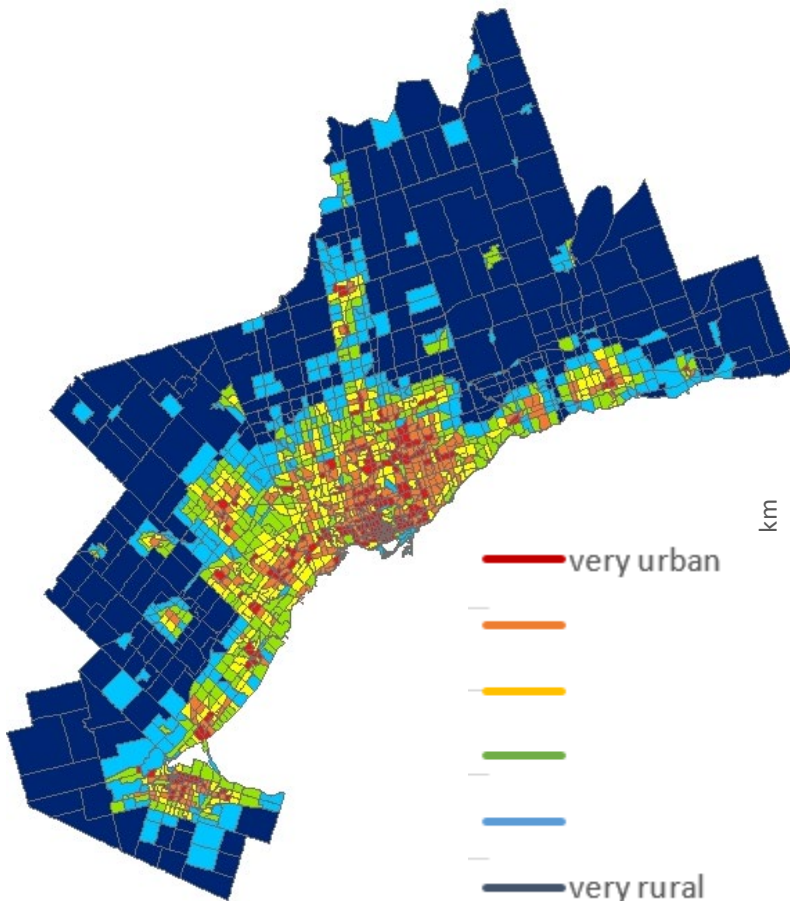
Mean VKT and PKT <u>per trip</u>

- VKT per trip growth = 1.5 km
- PKT per trip growth = 4 km

Mean VKT & PKT per trip in GTHA
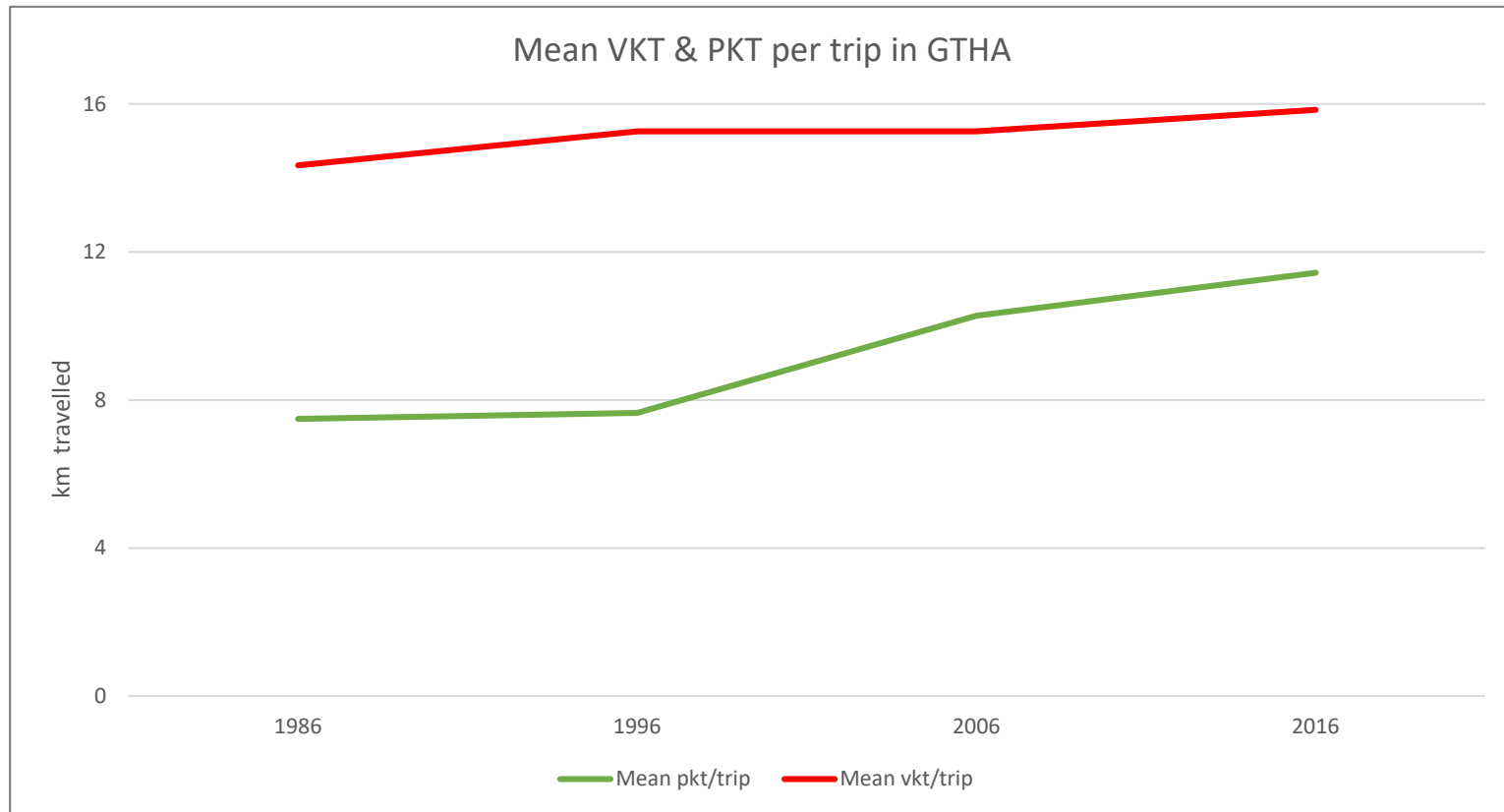
Model

Random effects model

- For TAZ *i* at time *t :*

$$
\begin{aligned}
VKT_i^t = \beta_0 &+ \beta_1 \ln(pop\ density)_i^t \\
&+ \beta_2 \ln(access\ by\ transit)_i^t \\
&+ \beta_3 \ln(avg.\ hh\ income)_i^t \\
&+ \beta_4 \ln(\%\ households\ with\ no\ car)_i^t \\
&+ \beta_5 \ln(\%\ seniors)_i^t \\
&+ \beta_{Yt}\ time\ dummy + \mu_i + \epsilon_i^t
\end{aligned}
$$

- β_{Yt} : captures the time-specific effects through year dummies
- μ_i : TAZ-specific time-invariant unobserved attributes
- PKT model has the same variables but a log-log function

VKT & PKT per trip 1986 – 2016
Random effects model

	VKT/trip	ln(PKT/trip)
population density (ln)	-0.788***	0.431***
rltv pop access by transit (ln)	-0.980***	0.633***
avg. hh income (ln)	0.300***	-0.048**
%hh 0 car (ln)	-0.205***	0.093***
% seniors (65 or above) (ln)	-0.024	-0.178***
1986 base year	.	.
1996	1.132***	0.219**
2006	1.962***	0.633***
2016	2.846***	0.765***
Observations	6864	6864
R2_within	0.03	0.18
R2_between	0.51	0.69
R2_overall	0.31	0.53

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

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VKT & PKT per trip 1986 – 2016
Random effects model

	VKT/trip	PKT/trip
population density	-	+
access by transit	-	+
avg. household income	+	-
% households with 0 cars	-	+
% seniors (65 or above)	.	+
Time point (1986 base year)	.	.
1996	+	+
2006	+	+
2016	+	+

VKT & PKT per trip 1986 – 2016
Random effects model

	VKT/trip	PKT/trip
population density	-	+
access by transit	-	+
avg. household income	+	-
% households with 0 cars	-	+
% seniors (65 or above)	.	+
Time point (1986 base year)	.	.
1996	+	+
2006	+	+
2016	+	+

VKT & PKT per trip 1986 – 2016
Random effects model

	VKT/trip	PKT/trip
population density	-	+
access by transit	-	+
avg. household income	+	-
% households with 0 cars	-	+
% seniors (65 or above)	.	+
Time point (1986 base year)	.	.
1996	+	+
2006	+	+
2016	+	+

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VKT & PKT per trip 1986 – 2016
Random effects model

	VKT/trip	PKT/trip
population density	-	+
access by transit	-	+
avg. household income	+	-
% households with 0 cars	-	+
% seniors (65 or above)	.	+
Time point (1986 base year)	.	.
1996	+	+
2006	+	+
2016	+	+

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VKT & PKT per trip 1986 – 2016
Random effects models with interactions with location

Main effects at rural area		VKT/trip	ln(PKT/trip)
population density (ln)		-0.613*	-0.05
rltv pop access by transit (ln)		-1.352***	0.015
avg. hh income (ln)		0.607**	-0.005
%hh 0 car (ln)		0.009	0.116**
% seniors (65 or above) (ln)		1.842***	-0.199**
Interactions with degrees of urbanity			
pop density*urbanity			
	2	0.097	0.507***
	3	-0.253	0.431***
	4	-0.346	0.181
	5	-0.572	0.17
	6	0.732*	0.049
rltv pop access by transit*urbanity			
	2	0.539*	0.742***
	3	0.649*	1.248***
	4	1.471***	0.692***
	5	1.686***	0.350**
	6	2.998***	0.189*
avg. hh income*urbanity			
	2	-0.031	0.032
	3	-0.365	-0.106
	4	-0.355	0.019
	5	-0.830***	-0.02
	6	-0.587**	-0.046*

Interactions with degrees of urbanity			
%hh 0 car*urbanity			
	2	-0.239	0.081
	3	-0.246*	-0.031
	4	-0.284*	-0.035
	5	-0.233	-0.138**
	6	-0.307*	-0.134**
%seniors*urbanity			
	2	-1.769**	0.214
	3	-2.061***	0.03
	4	-2.413***	0.037
	5	-2.651***	0.005
	6	-2.793***	0.165*
1986 base year			
	1996	1.052***	0.177**
	2006	1.837***	0.702***
	2016	2.669***	0.864***
rural base level of urbanity			
	2	4.499	0.957
	3	10.237***	4.605***
	4	11.377**	4.312***
	5	18.995***	4.796***
	6	7.108*	5.618***
Obs		6864	6864
R2_within		0.05	0.23
R2_between		0.58	0.81
R2_overall		0.36	0.63

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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Very rural areas:

Income and **share of seniors** contribute the most to VKT here.

Very urban areas:

generate very high VKT **despite** high population density and access by transit.

Conclusions

Over three decades in GTHA:

- Despite improvements in the road network, auto travel times have increased (combination of induced demand and growth in population)

Conclusions

- Kilometers travelled by vehicles and transit have more than doubled
- Also, people are travelling farther(1.5 more km by car and 4 more km by transit)
- Highest VKT growth → rural (but not the very rural) areas
- Highest PKT generation and growth → very urban areas

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Conclusions

- Approx. 50% variation in VKT and 70% variation in PKT in GTHA can be explained by:
  - population density
  - access by transit
  - household income
  - % households with zero cars
  - % seniors

- The determinants' effects vary significantly across space, but not time

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Part II – Land value developments

A preliminary analysis

Data

- **Teranet land transaction value data**

- **Time frame:** 2001, 2006, 2011, 2016

- **Spatial unit of analysis:**

  7,904 Dissemination Areas (DAs) @ 4 time points = 31,616

  (2978 DAs with no transactions in one or more of the time points excluded)
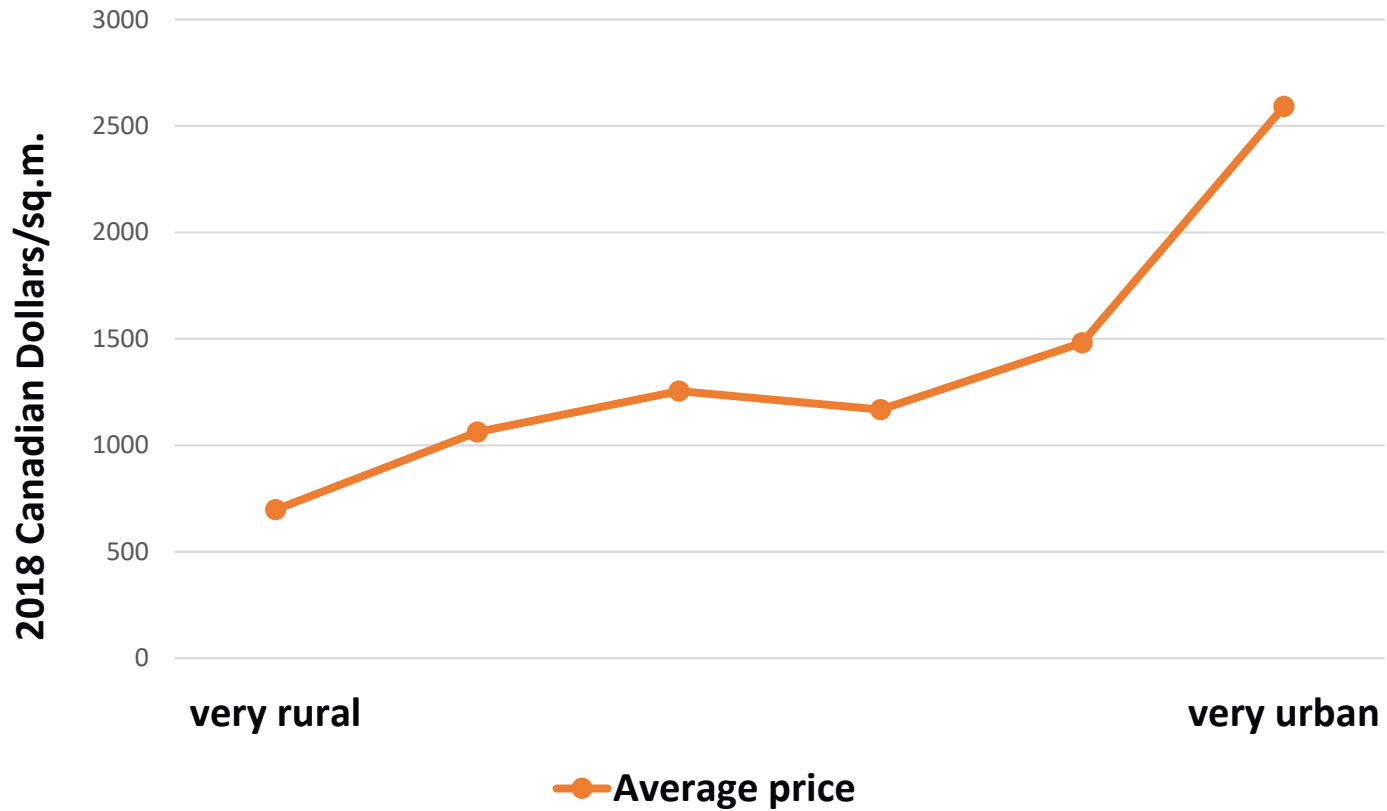
- **Socio-economic variables**

Census + TTS

- **Accessibility variables**

  Calculated at TAZ and DA levels

Average land value price per sq. m. over time

Average land value price per degree of urbanity

Land value = f(accessibility, socio-demographics, urban form)

Findings

- Land values in GTHA have been increasing in general since early 2000s and specifically after 2011

- **Population density** and **access to jobs by transit** are the most influential determinants (both proxies for centrality)

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Findings

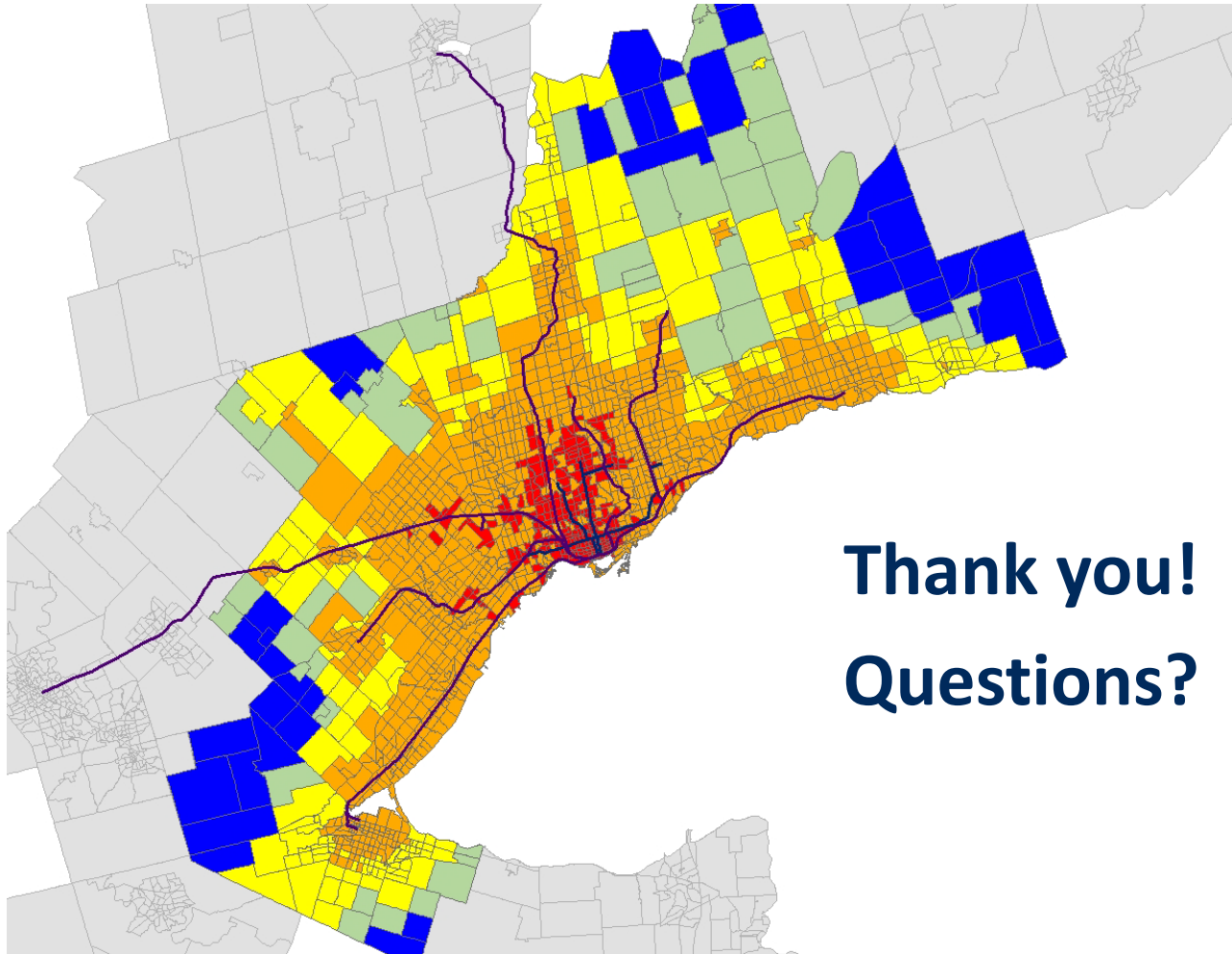Highest likely impacts on land value result from:

- Increasing population density in the very rural areas
- Increasing job accessibility by transit in the very urban areas

Next steps

Investigate:

- Types of development (residential, industrial, office)
- The role of land value dynamics on affordable housing
- Interconnections between land value, accessibility and agglomeration effects

Thank you!

Questions?

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