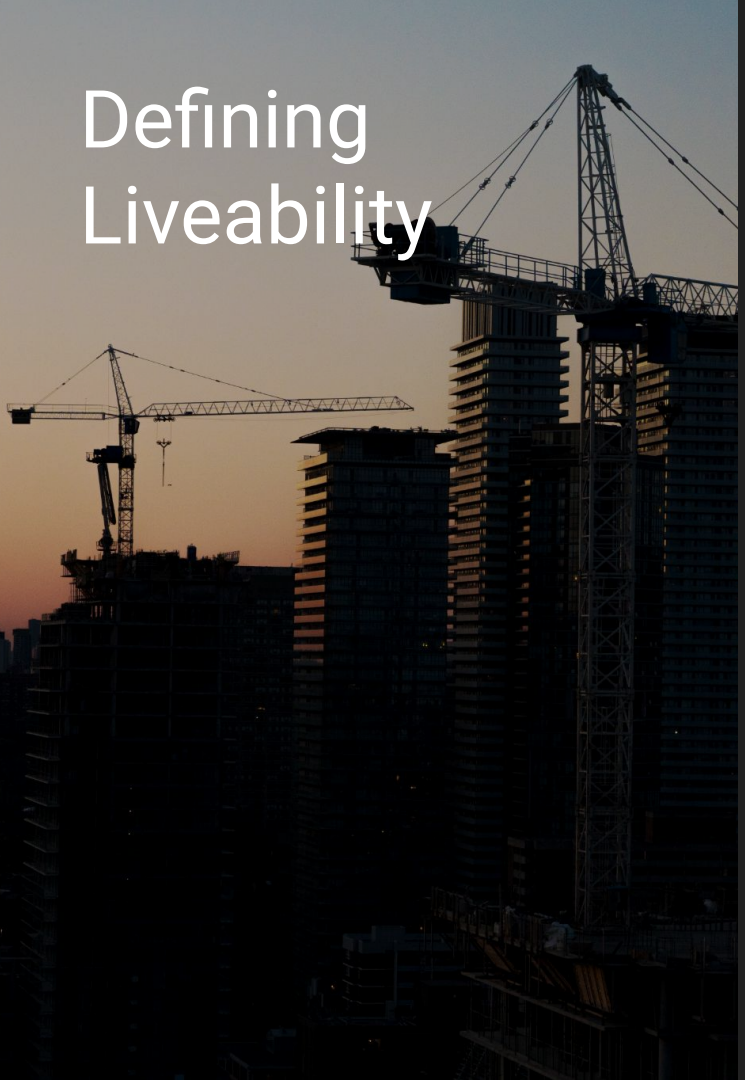
ISSC Case Competition: How Liveable is Toronto?

Prospective Analytics
Sergio Zheng Zhou, Eric Zhu, Jing Yuan Zhang, Muhammad Tsany

All pictures taken by Eric Zhu



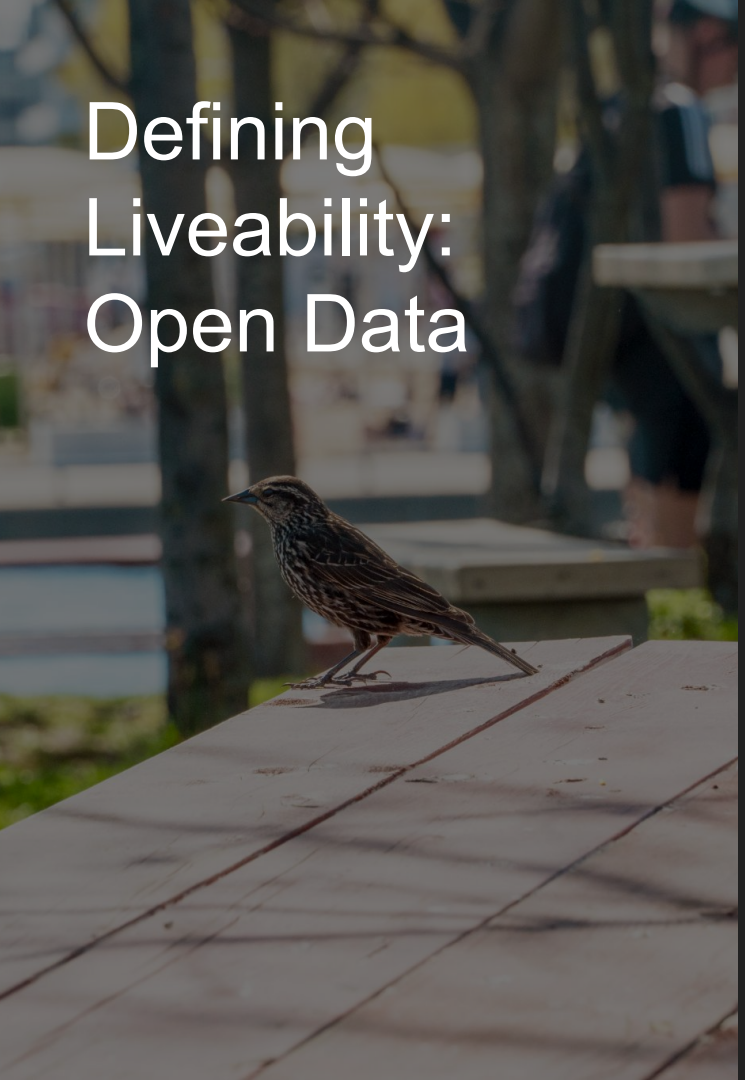
Defining Liveability

- Rating constructed based on “The Economist’s” *Global Liveability Index 2021*
- Neighbourhood liveability scores constructed with 5 weighted categories:
  - Stability (25%)
  - Healthcare (20%)
  - Education (10%)
  - Infrastructure (20%)
  - Culture and Environment (25%)

Reference:
https://pages.eiu.com/rs/753-RIQ-438/images/global-liveability-index-2021-free-report.pdf?mkt_tok=NzUzLVJJUS00MzgAAAF9j-2A_8m7fB1aWnNABQKZ8QzBzVbqAs9mVmESiJFHj7htFqi7PKlJbMaV_7rpqGNfvBuKEGs4Xn7DRxe5it5dGGJqofkPmLMUAOqwlYIoYp4hUg

Methodology

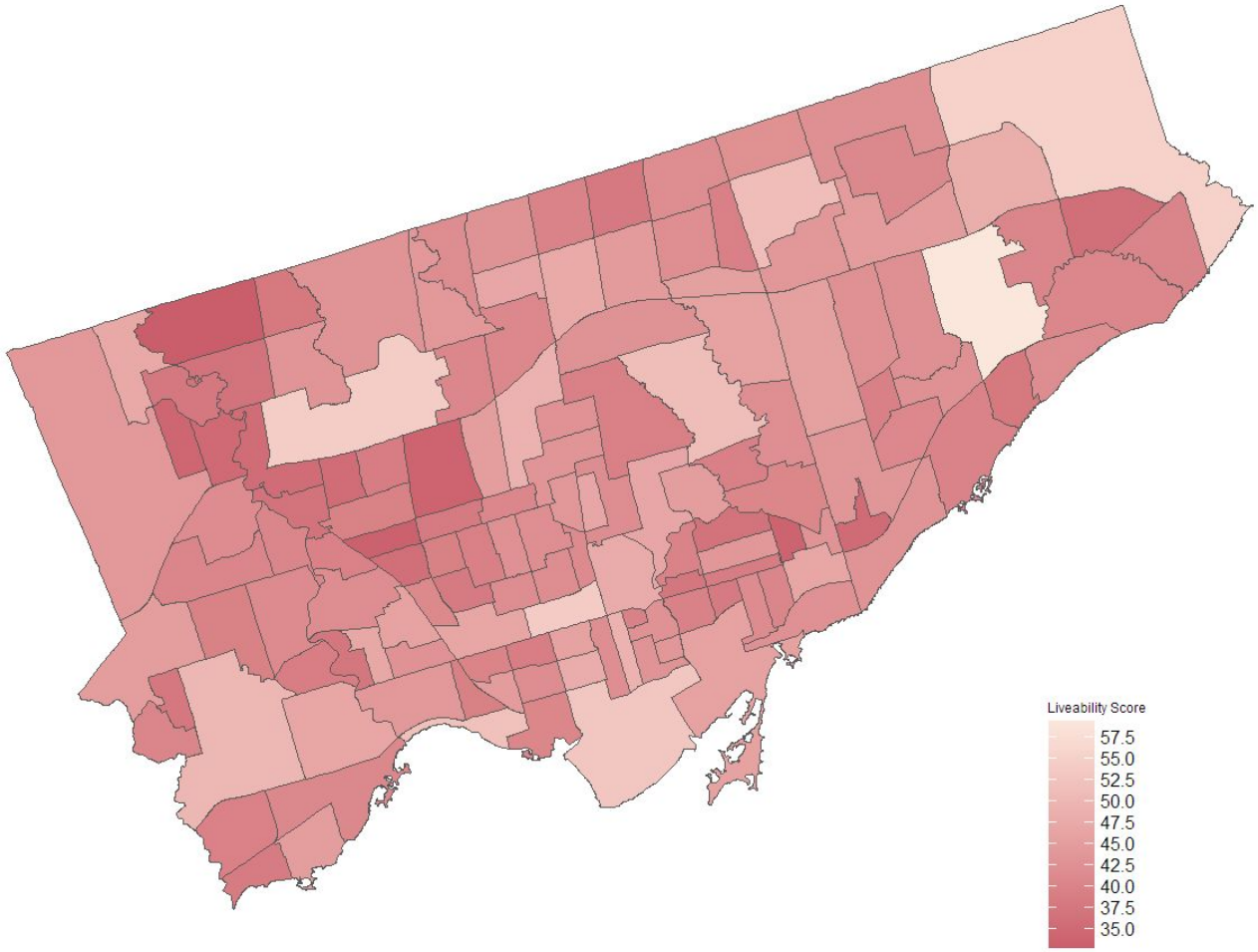
Defining Liveability: Open Data



- Stability (25%)
  - Petty and violent crime rates
- Healthcare (20%)
  - COVID-19 Vaccination and testing Sites
  - Mental health facilities
  - Healthcare providers
  - Premature mortality rates
- Education (10%)
  - Youth and adult education support centres
- Infrastructure (20%)
  - Water main breaks
  - Social housing
  - Walking score
- Culture & Environment (25%)
  - Youth recreation centres
  - Cultural spaces
  - Places of worship
  - Green space count

Liveability Scores Across Toronto

Neighbourhoods of Toronto, Canada



Clustering and Two Sample T-Test

- Clearly most neighbourhoods are darker, with some neighbourhoods having lighter colours
  - Cursory visual evidence of possible nesting structure
- Fit k-means model to differentiate
  - k=2
  - Examine scores in possible nesting structure
    - **Cluster 1 - Higher liveability scores**
    - **Cluster 2 - Lower liveability scores**
- Performed two sample t-test to gather evidence of approach appropriateness
  - p-value$<2.2 \cdot 10^{-16}$
  - T-statistic = 12.50101
  - df = 54.25
  - Sample estimates
    - Mean of Cluster 1 = 47.86
    - Mean of Cluster 2 = 40.03

Defining Liveability: 2016 Statistics Canada Census

- Age
- Gender
- Income
- Education
- Ethnic Origin
- Language
- Employment

Evidence of Multicollinearity - VIF

- Used common rule of **VIF>10** as evidence of strong multicollinearity
- Most covariates had **extremely high** VIF values
  - Total Visible Minority: 262693.7
  - Employed: 125686.4
  - Working Age (25 - 54 years): 49817
- Strong evidence of multicollinearity hurts analysis
  - A “full model” using all available covariates isn’t meaningful
- Must choose covariates meaningfully
  - Arrived at analysing income levels + education levels
  - Meaningful for prospective immigrants

How does **income** and **education** level relate to liveability scores across Toronto and within higher & lower liveability **neighbourhoods**?

Linear Model and Linear Mixed Model Regression Analysis

Assumptions

- For every **linear** model constructed, the following assumptions are revised:
  - Linearity
  - Homoscedasticity
  - Independence
  - Normality
- For every **linear mixed model** constructed, the following assumptions are revised:
  - Continuous response variable
  - Independence
  - Normality
  - Homoscedasticity
  - Normality of random effect

Cluster 1: Income and Education

Estimates, 95% Confidence Interval, P-Values for Cluster 1 Income and Education Regression

	Estimate	2.5%	97.5%	pval
(Intercept)	42.2845394	39.6376080	44.9314708	0.0000
`Under $25K`	0.0022862	-0.0001827	0.0047551	0.0683
`25K−49.9k`	0.0008594	-0.0026982	0.0044170	0.6257
`50K−89.9k`	-0.0003596	-0.0031972	0.0024779	0.7977
`$90k and over`	0.0025931	0.0010437	0.0041426	0.0018
`No Degree`	-0.0004728	-0.0029265	0.0019810	0.6971
`Highschool Degree`	0.0013784	-0.0005656	0.0033224	0.1582
`Postsecondary Degree`	-0.0010654	-0.0021373	0.0000065	0.0513

Cluster 2: Income and Education

Estimates, 95% Confidence Interval, P-Values for Cluster 2 Income and Education Regression

	Estimate	2.5%	97.5%	pval
(Intercept)	35.9040482	34.5338855	37.2742109	0.0000
`Under $25K`	-0.0000107	-0.0011084	0.0010870	0.9846
`25K−49.9k`	0.0027358	0.0002056	0.0052660	0.0344
`50K−89.9k`	-0.0033538	-0.0053046	-0.0014029	0.0010
`$90k and over`	0.0014393	0.0001406	0.0027380	0.0302
`No Degree`	0.0001576	-0.0011253	0.0014405	0.8078
`Highschool Degree`	0.0000398	-0.0013306	0.0014102	0.9541
`Postsecondary Degree`	0.0004923	-0.0002615	0.0012460	0.1979

City of Toronto: Income and Education*

Estimates, 95% Confidence Interval, T-Values for Toronto Income and Education Regression

	Estimate	2.5%	97.5%	Tval
Intercept	38.9277559	1.3294764	12.1034959	13.1428
Under $25K	0.0005405	2.0952872	2.6538764	1.0250
$25K-49.9k	0.0023452	31.9255979	45.9772471	2.4787
$50K-89.9k	-0.0025792	-0.0004735	0.0015546	-3.3525
$90k and over	0.0018272	0.0005323	0.0041716	3.8714
No Degree	-0.0004103	-0.0040718	-0.0011116	-0.7109
Highschool Degree	0.0008995	0.0009234	0.0027388	1.7760
Postsecondary Degree	-0.0000606	-0.0015222	0.0006976	-0.2071

*Random intercept on liveability cluster


Conclusion

Overall Findings

- **$90k and over** income bracket was significant in the positive direction in both clusters and at the city level.

- Contrarily, in the lower liveability scores cluster, the $50k-$89.9k bracket was significant in the **negative** direction and find $25k-$49.9k bracket has a **positive** association.

Limitations and Next Steps

- Limitations
  - All datasets were the most recent and openly available from OpenDataToronto.
  - Confounders

- Next Steps
  - Examine individual neighbourhoods and condition education on other covariates.
  - Advise City of Toronto to look into possible gentrification of city and policy remedies.
    - Logistic modelling
  - Performing the same analysis on a country level.