The Impact of Considering Equity in Optimization for Urban Planning

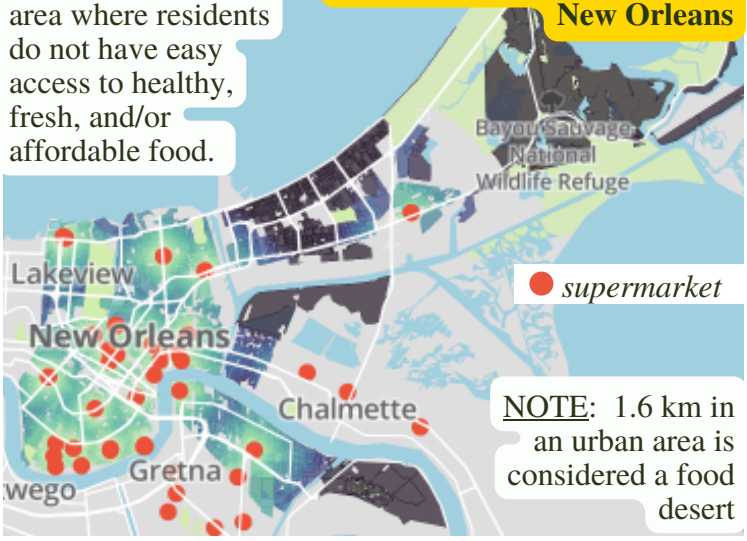
If we want to increase the number of a given amenity in a city, where should they be placed to maximize population access?

Well known "facility location model" can be used to find new locations for amenities that minimize the population weighted mean distance.

Problem: Intervention strategies, such as minimizing population weighted distance to grocery stores, further ignore the communities traveling the furthest as outliers in the solution.

Food Desert: An area where residents do not have easy access to healthy, fresh, and/or affordable food.

Case Study: Supermarkets in New Orleans



To address food deserts, and existing inequities, we propose an approach that not only minimizes population weighted distance, but also takes into account inequality.

We look to Environmental Justice literature [1] [2] to find a different objective function.

Kolm-Pollak Equally Distributed Equivalent (EDE)

$$\Xi = -\frac{1}{\kappa} \ln \left[\frac{1}{|R|} \sum_{r \in R} e^{-\kappa z_r} \right]$$

- Incorporates both the center and the spread of the distribution of the individual experiences
- Captures the experience of an "average" individual more accurately than the population mean

Downfall: nonlinearity of the Kolm-Pollak EDE makes optimizing over it non trivial.

Theorem 1 [3]: Linear Proxy of the Kolm-Pollak EDE

$$\sum_{r \in R} \sum_{s \in S} y_{r,s} p_r e^{-\kappa d_{r,s}} \qquad \text{(LP)}$$

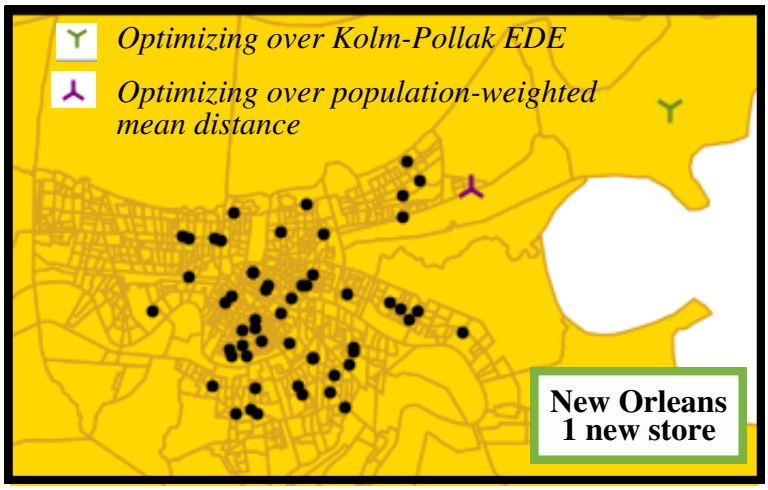
Optimizing (LP) in a Facility Location Model gives the same solution as optimizing the Kolm-Pollak EDE.

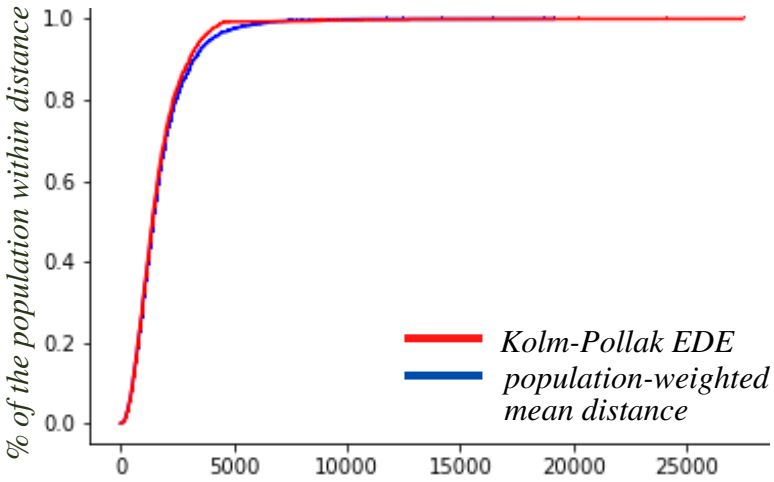
(LP) is linear, therefore the computational burden is no more than the existing traditional approaches

Computational Results

We have results for supermarket access in the largest 500 cities in the United States.

Question 1: *If you can open additional amenities, where should they go to best improve equitable access?*





- Mean distance does not increase much when optimizing over Kolm-Pollak EDE
- Maximum distance any area must travel to a supermarket is significantly reduced with Kolm-Pollak Formulation

Question 2: *If you want to provide a given level of equitable access, what is the minimum number of additional amenities that you need? (and where should you place them?)*

Questions 1 and 2 are equivalent in terms of the mathematical formulations, however, from a policy making standpoint the answer to question 2 is a stronger result.

Example: We calculate the **mean level of equitable access** of the 500 largest U.S. cities, 2.6 km. New Orleans is currently ranked 493. However, we found that to achieve the mean access, they only need to add **one new store.**

Conclusion: Optimize over the Kolm-Pollak EDE in a facility location whenever equity is a factor.

References: https://sites.google.com/view/miniposter-references/