New Route, New Faces?: Measuring Changes in the Exposure to Diversity on Transit Using Social Interaction Potential

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I. Study Purpose

Map changes in an individual's commute from self-collected, origin-destination data. Develop a modified approach in utilizing the Social Interaction Potential (SIP) metric to quantify levels of contact between individual commutes. Test the significance of changes in riders' exposure to diversity with the addition of new bus services.

II. Research Design

Social Interaction Potential (SIP) Index Development and Change Measurement

1. Using a continuous indicator of interest
When formulating the interaction based on riders' age, the index is defined as:

$$\sum_i \sum_{j \neq i} \left((\alpha_i - \alpha_j)\beta_{i,j} \right)^2$$

where i and j are index elements, α is the continuous variable under analysis (age), and β is the percent of spatial overlap between the travel routes for i and j.

2. Using a binary indicator of interest
When formulating the interaction based on riders' income, the index is defined as:

$$\sum_i \sum_{j \neq i} \begin{Bmatrix} (\beta_{ik,jk})^2 \ if \ k_i \neq k_j \\ 0 \ otherwise \end{Bmatrix}$$

where i and j are index elements, k is the binary variable under analysis (income), and β is the percent of spatial overlap between the travel routes for i and j.

These indices consider the social difference and spatial colocation for each unique ordered pair of individuals. Thus, as shown in the figure below, we can observe similar SIP values for (a) high spatial overlap, low age difference, (b) average spatial overlap, average age difference, and (c) low spatial overlap, high age difference.
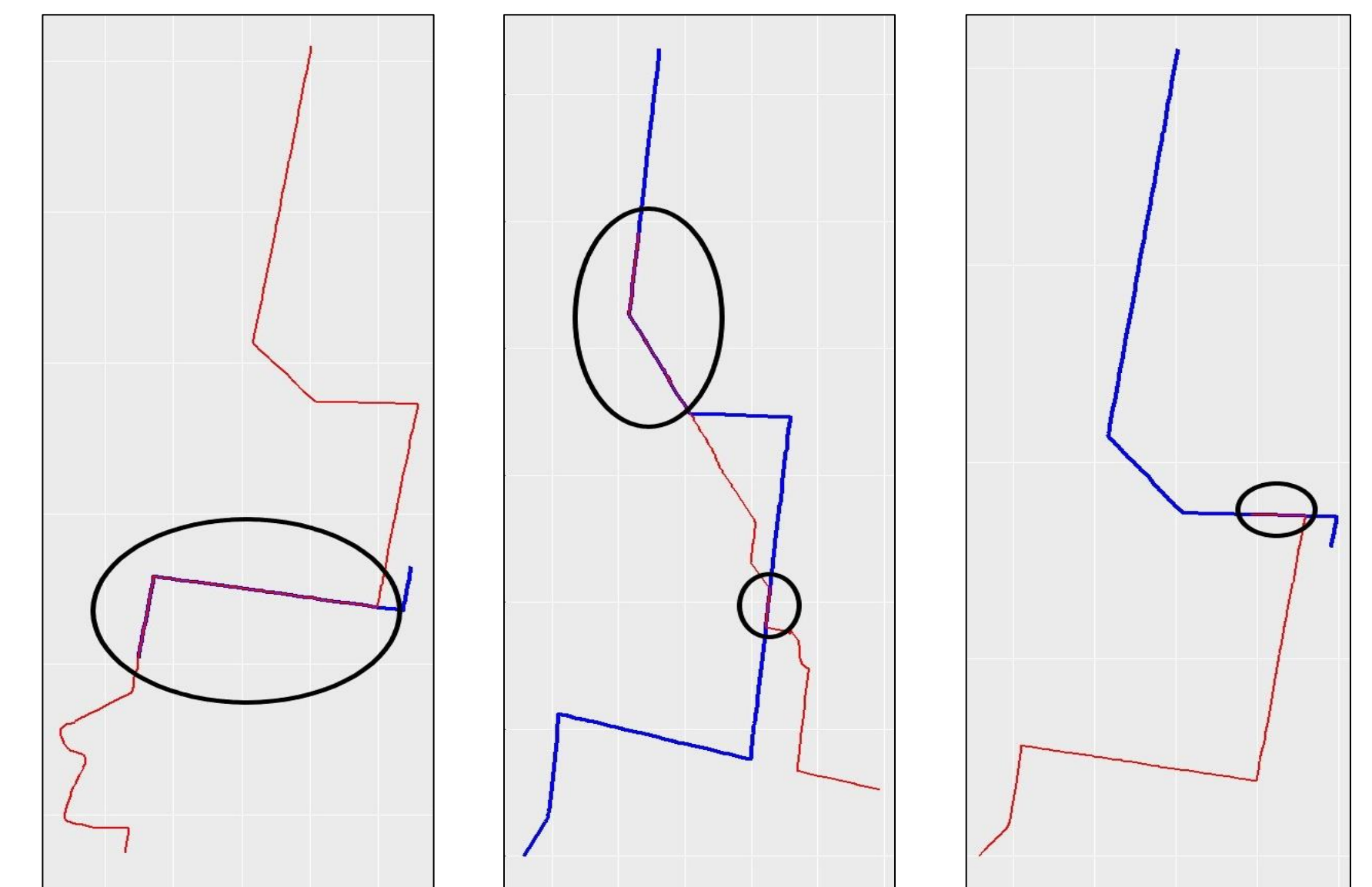
III. Results

The addition of Route 49 to the SEPTA's transit system is associated with a statistically significant increase in the exposure to income and age diversity.

- The box plots below illustrate the increase in mean distribution of SIP values for income and age measured before and after the addition of Route 49.

- "The average difference in means between the age index measured with the Route 49 and without the Route 49 is 8,025.92 (95% CI: 6,836.49, 9,215.34), and this difference is highly statistically significant (t(182) = 19.26, P < .001)."

- "The findings for the index when using the binary income indicator are similar. The average difference in means is 6.78 (95% CI: 6.08, 7.47) between index values measured with the Route 49 and those without the new bus service."

- Exposure to diversity plays a crucial role in fostering social cohesion. This unintended consequence of public transit deserves investments and restructuring to further increase resilience within communities and benefit people of all race, age, and socioeconomic class.
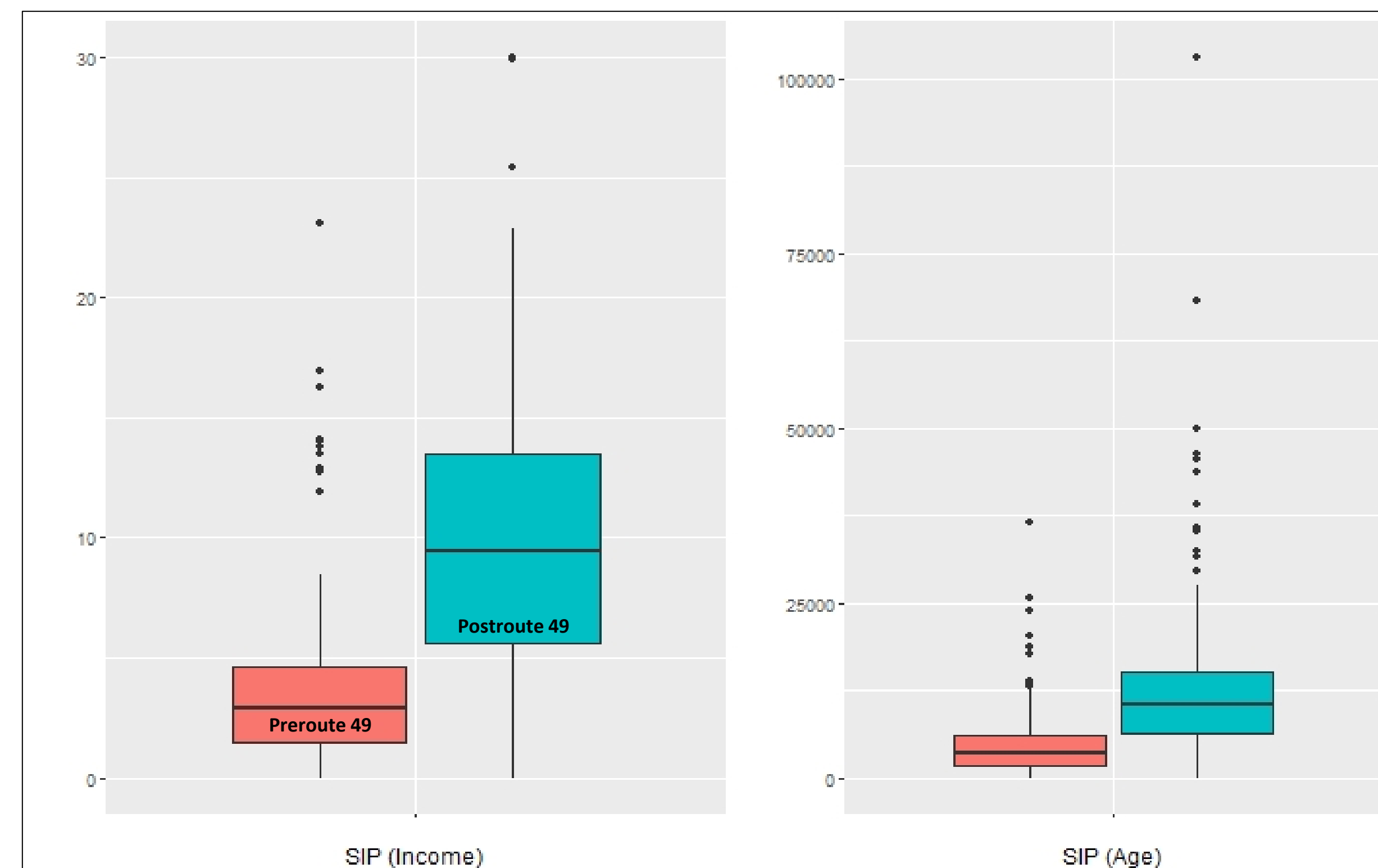
IV. Sources

Farber S, Neutens T, Miller HJ, Li X. The Social Interaction Potential of Metropolitan Regions: A Time-Geographic Measurement Approach Using Joint Accessibility. Ann Assoc Am Geogr. 2013 May 1;103(3):483–504.

Ryerson MS, Hansen M. Capturing the impact of fuel price on jet aircraft operating costs with Leontief technology and econometric models. Transp Res Part C Emerg Technol. 2013 Aug;33:282–96.

R Core Team. R: A language and environment for statistical computing [Internet]. Vienna, Austria: R Foundation for Statistical Computing; 2020. Available from: https://www.R-project.org/

Lovelace R, Ellison R. stplanr: A Package for Transport Planning. R J. 2019;10(2):7.