**Multimodal spatial availability: a research proposal**

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**RESUMEN**

Spatial inequalities in cities is an increasing concern in the transportation literature (e.g., between socio-economic groups (Iglesias et al., 2019), including from the perspective of accessibility to education (Ye et al., 2018), healthcare (Sharma & Patil., 2021), transportation infrastructure (Mooney et al., 2019), and employment (Páez et al., 2013)). To quantify inequities, *accessibility measures* have been applied in the literature as they capture the potential for interaction of population at a location with opportunities, based on transportation systems and land-use. A variety of accessibility methods have been applied to answer specific research questions: many use the gravity-based accessibility model proposed by (Hansen, 1959) or some sort of modification (e.g., cumulative opportunity measure, two-step floating catchment approach (2SFCA) (Merlin & Hu, 2017)). Many papers also produce findings that can be translated into policy recommendations (e.g., prioritize the connectivity of transit systems in disadvantaged neighbourhoods (Park et al., 2021)).

Spatial inequities often arise from differences by mode type (e.g., commuting using a car as opposed to transit). However, methods implemented in current multi-modal accessibility literature are lacking as a result of obfuscated interpretation as demonstrated by Soukhov et al., 2023. To illustrate, Hansen-type accessibility is calculated for a population at an origin of 10,000 jobs and this value represents how many opportunities can be potentially interacted with. But what does it mean for transit-commuting population and car-commuting population in this origin? The car-commuting mode may be able to access more opportunities and this access removes opportunity access for the transit-commuting mode. The different travel costs between modes creates competition in access to opportunities that conventional accessibility measures do not capture.

In this spirit, this paper proposes an extension of spatial availability (Soukhov et al., 2023), a singly-constrained competitive accessibility measure, for the context of multi-modal accessibility analysis. We propose to illustrate the features of spatial availability that lend itself to multi-modal analysis. We then propose demonstrate its use on the case study of Low Emission Zones in Madrid (Spain) and highlight how this policy intervention changes the accessibility of populations using different modes. In summary, spatial availability can be used to create and interpret multi-modal policy intervention scenarios unlike previous accessibility methods: this creation and interpretation can help regions envision a more sustainable and equitable access-to-opportunity landscape.

**Keywords**: multi-modal accessibility, equity analysis, policy scenario analysis

**REFERENCES**

Hansen, W. G. (1959). How Accessibility Shapes Land Use. *Journal of the American Institute of Planners*, *25*(2), 73–76. <https://doi.org/10.1080/01944365908978307>

Iglesias, V., Giraldez, F., Tiznado-Aitken, I., & Muñoz, J. C. (2019). How Uneven is the Urban Mobility Playing Field? Inequalities among Socioeconomic Groups in Santiago De Chile. *Transportation Research Record*, *2673*(11), 59–70. <https://doi.org/10.1177/0361198119849588>

Merlin, L. A., & Hu, L. (2017). Does competition matter in measures of job accessibility? Explaining employment in Los Angeles. *Journal of Transport Geography*, *64*, 77–88. <https://doi.org/10.1016/j.jtrangeo.2017.08.009>

Mooney, S. J., Hosford, K., Howe, B., Yan, A., Winters, M., Bassok, A., & Hirsch, J. A. (2019). Freedom from the station: Spatial equity in access to dockless bike share. *Journal of Transport Geography*, *74*, 91–96. <https://doi.org/10.1016/j.jtrangeo.2018.11.009>

Park, K., Rigolon, A., Choi, D., Lyons, T., & Brewer, S. (2021). Transit to parks: An environmental justice study of transit access to large parks in the US West. *URBAN FORESTRY & URBAN GREENING*, *60*. <https://doi.org/10.1016/j.ufug.2021.127055>

Páez, A., Farber, S., Mercado, R., Roorda, M., & Morency, C. (2013). Jobs and the Single Parent: An Analysis of Accessibility to Employment in Toronto. *Urban Geography*, *34*(6), 815–842. <https://doi.org/10.1080/02723638.2013.778600>

Soukhov, A., Paez, A., Higgins, C. D., & Mohamed, M. (2023). Introducing spatial availability, a singly-constrained measure of competitive accessibility | PLOS ONE. *PLOS ONE*, 1–30. https:// doi.org/10.1371/journal.pone.0278468

Sharma, G., & Patil, G. R. (2021). Public transit accessibility approach to understand the equity for public healthcare services: A case study of Greater Mumbai. *Journal of Transport Geography*, *94*, 103123. <https://doi.org/10.1016/j.jtrangeo.2021.103123>

Ye, C., Zhu, Y., Yang, J., & Fu, Q. (2018). Spatial equity in accessing secondary education: Evidence from a gravity-based model: Spatial equity in accessing secondary education. *The Canadian Geographer / Le Géographe Canadien*, *62*(4), 452–469. <https://doi.org/10.1111/cag.12482>