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Accessibility inequality across Europe: a comparison of 15-minute pedestrian accessibility in cities with 100,000 or more inhabitants

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Research question

- How unequal are the current pedestrian accessibility conditions in European cities?

Methodology

- **Case study and data sources**
  - European cities with more than 100,000 inhabitants (585 cities)
  - Administrative boundaries: Eurostat/ GISCO geographical data - Urban Audit 2020 (864 cities)
  - Population data: Eurostat for the period 2011–2020 (the most recent figure was used)
  - Street network: Pedestrian network from OpenStreetMap (OSM)

Methodology

- **Origins**
  - All nodes in the pedestrian network
  - Uber's Hexagonal Hierarchical Spatial Index (H3), level 10 (~65.9 meters edge length), covering the entire city.
    - Our samples of cities had between 439 (Santa Coloma de Gramenet, Spain) and 56,941 (Berlin, Germany) hexagons
  - Final city dataset: 4,347,078 observations, 585 cities

Methodology

Destinations

- All points of interest (POIs) whose OSM tags had the following keys: **amenity, craft, leisure, office, shop, and tourism**. Also all non-residential buildings' data (when destination is represented as a polygon)
  - All POIs whose "access" was identified as "no", "private" or "customers" were excluded from the dataset.
- To control for **edge effects**: linear buffer of 1 km for each city boundary

Methodology

- **Accessibility measures (place-based)**
  - **Total Destinations:** measures accessibility to all destinations (a cumulative opportunities measure)
  - **Variety**, which describes the assortment of accessibility to 10 opportunity types (range between 0 an 10)

  - 15 minutes of travel by foot, considering **3 different walking speeds**: 0.7 m/s, 0.9 m/s and 1.1 m/s (630 m, 810 m and 990 m respectively)
  - **Opportunity types**: (1) Education, (2) Supermarkets, markets, and food shops, (3) Healthcare, (4) Sports and recreation, (5) Culture and leisure, (6) Parks and other green areas, (7) Eating and drinking establishments, (8) Retail, (9) Religious, and (10) Public service

Methodology

- **Inequality indicators**
  - pseudo-Gini coefficients for both accessibility variables:
    - **Territorial-based Gini (T-Gini):** considering all observation points (hexagons) for each city.
    - **Population-based Gini (P-Gini):** Estimation of the number of residents per hexagon, using the Global Human Settlement Layer (GHS population grid), constituting a ‘weight’ for each hexagon

Results

(1) Pedestrian accessibility in European cities

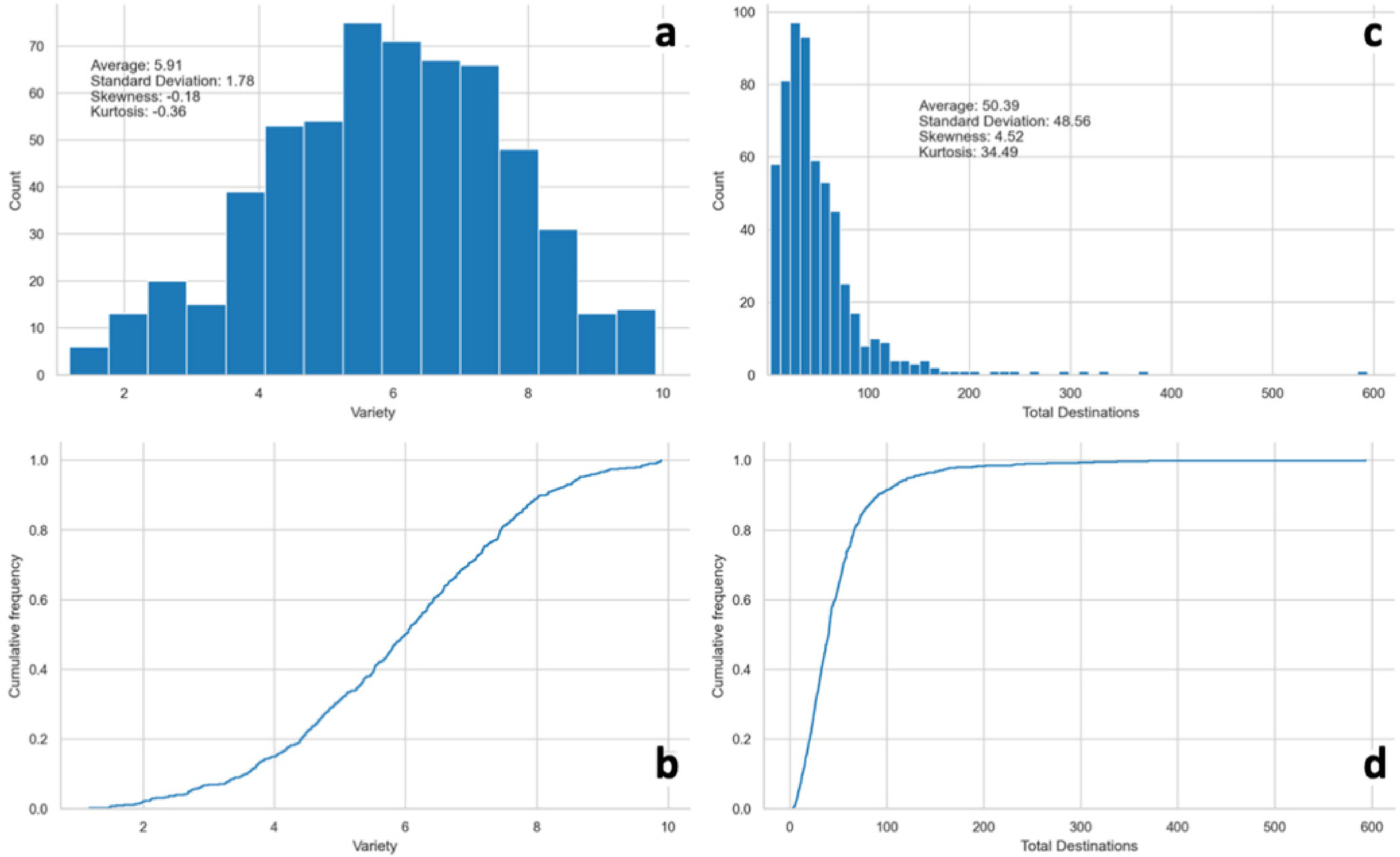
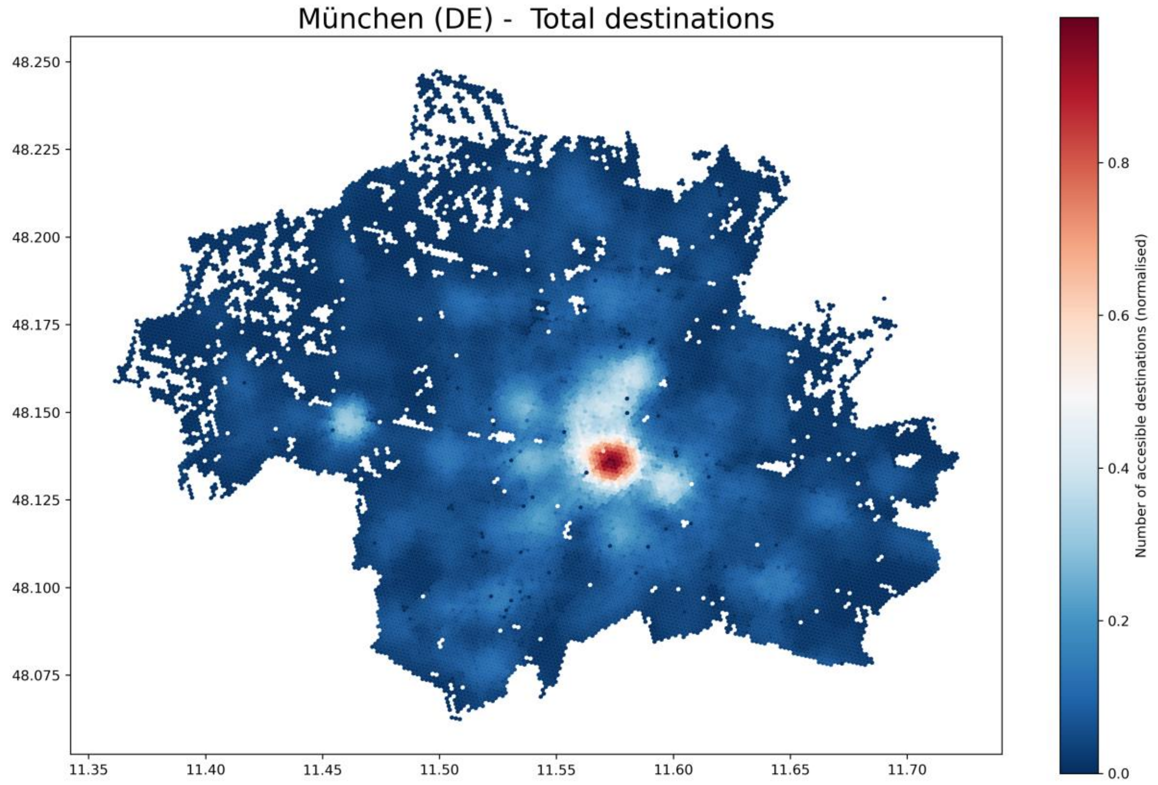
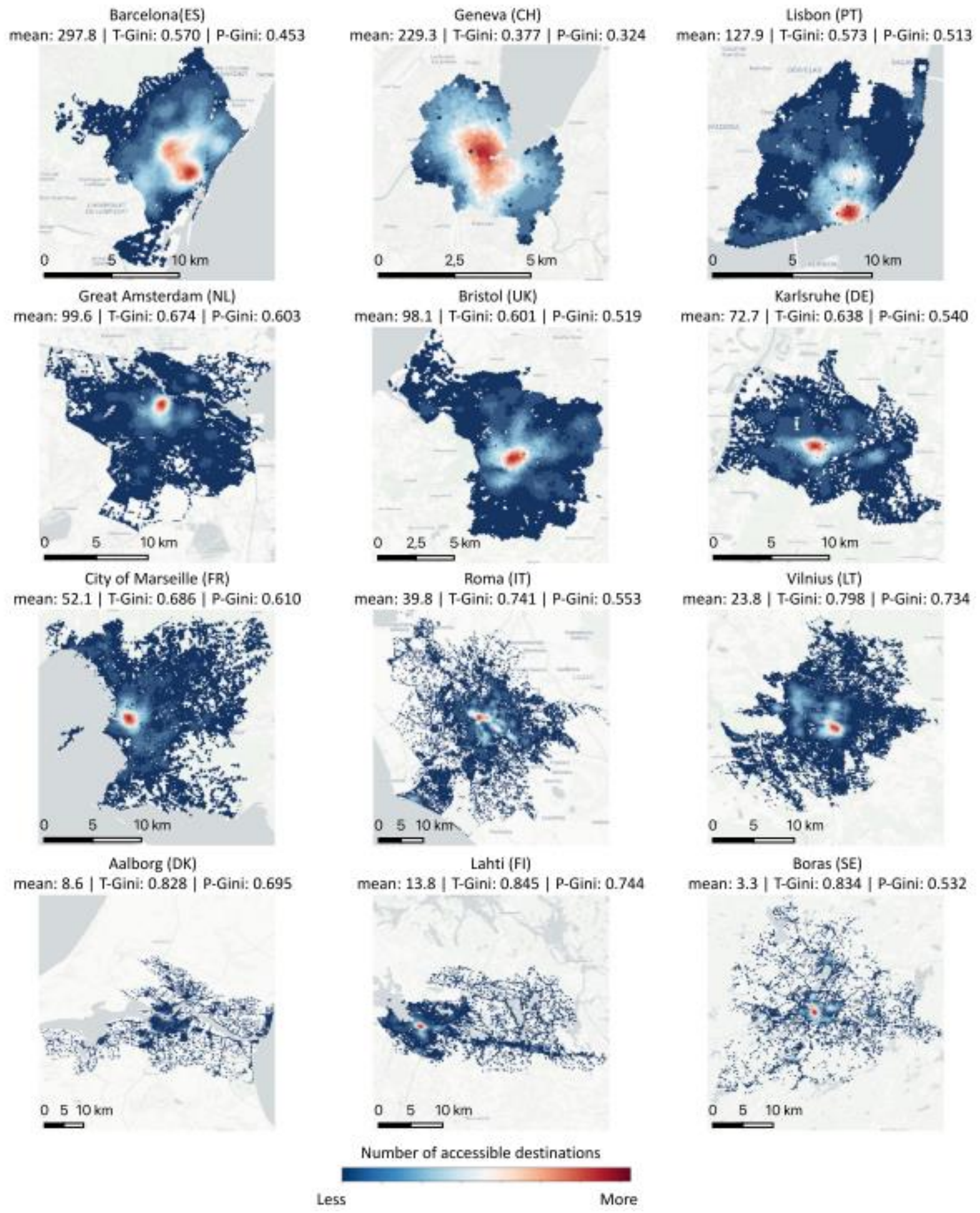


Fig. 1 **Histograms and cumulative frequency charts.** The proposed graphs illustrate the values for total destinations and variety counts for the analyzed European cities. Figures (**a**) and (**b**) illustrate the variety values, while (**c**) and (**d**) correspond to total destination counts.

Results

(2) Pedestrian accessibility within European cities

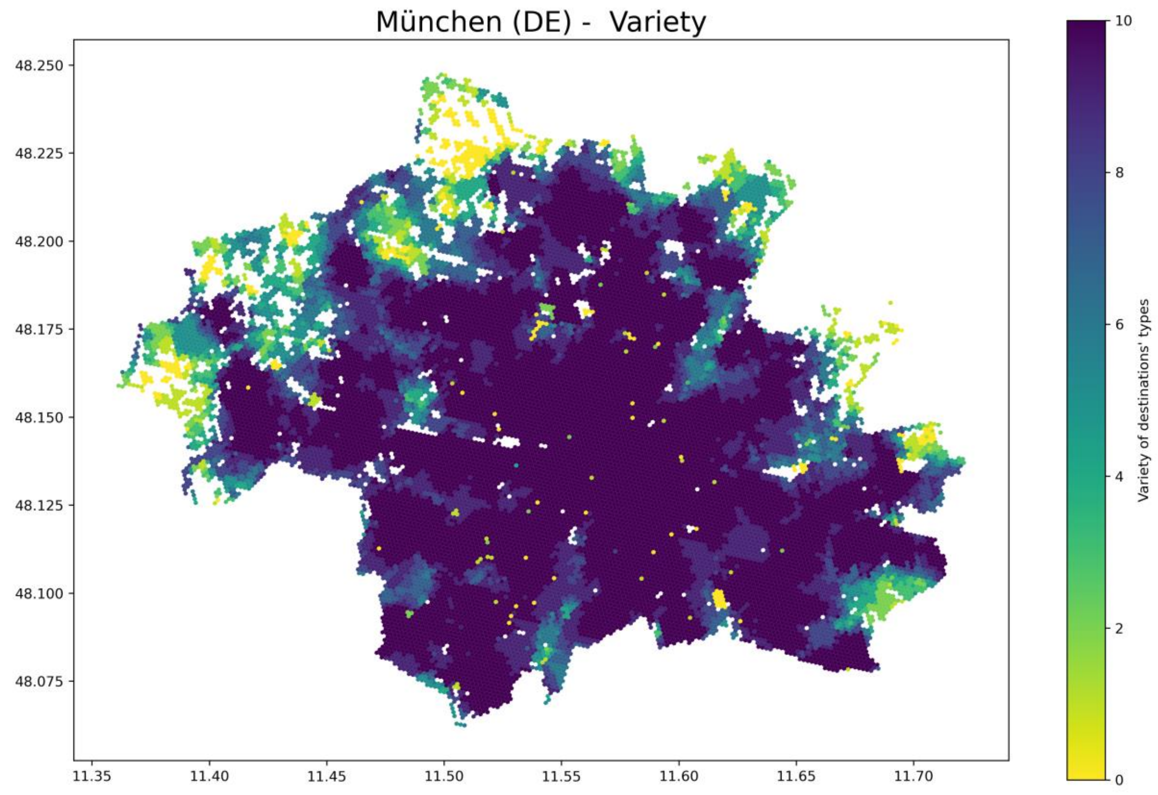




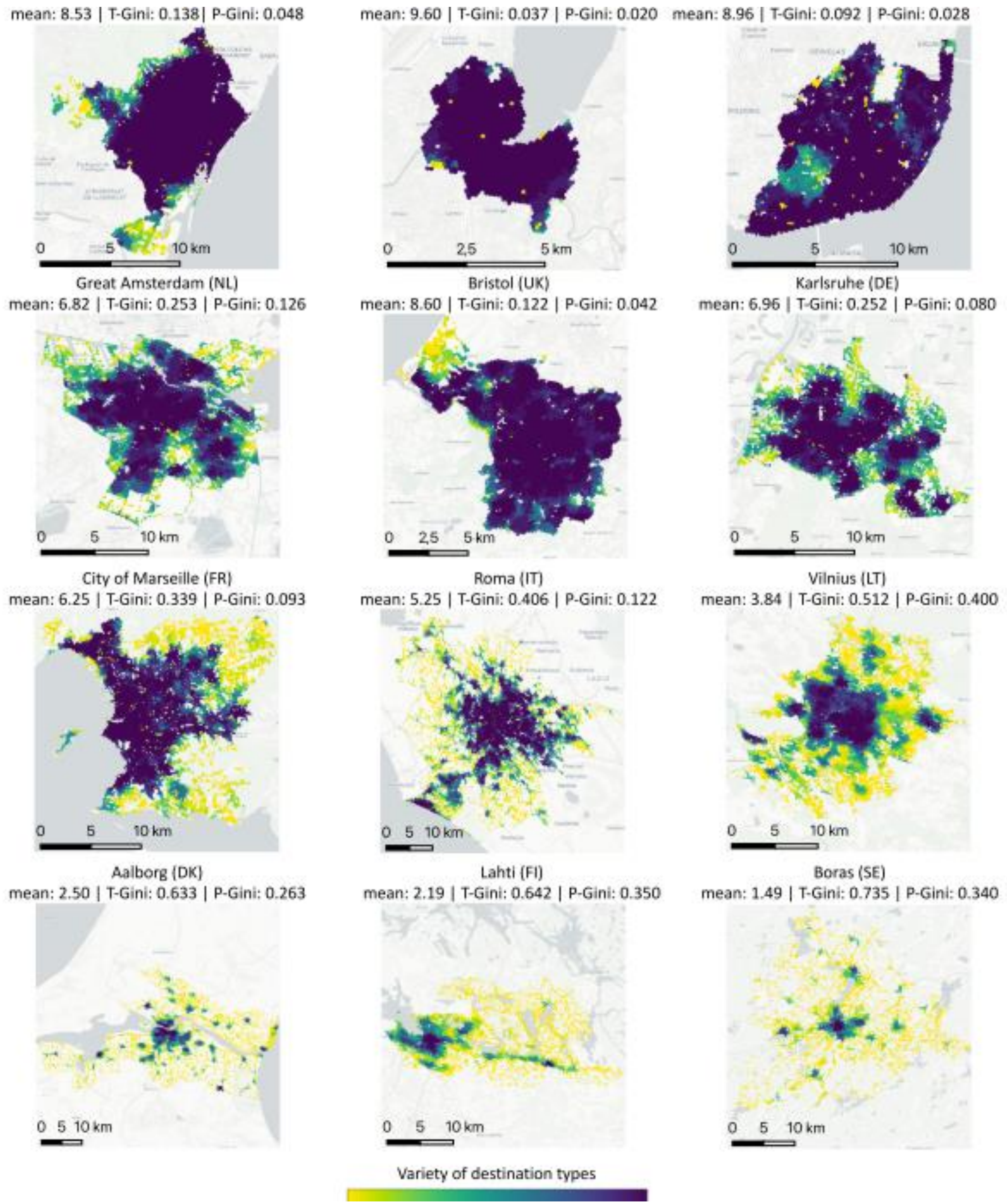
Total destinations within a 15-minute walk

Results

(2) Pedestrian accessibility within European cities



Variety of destination types accessible within a 15-minute walk



Results

(2) Pedestrian accessibility within European cities

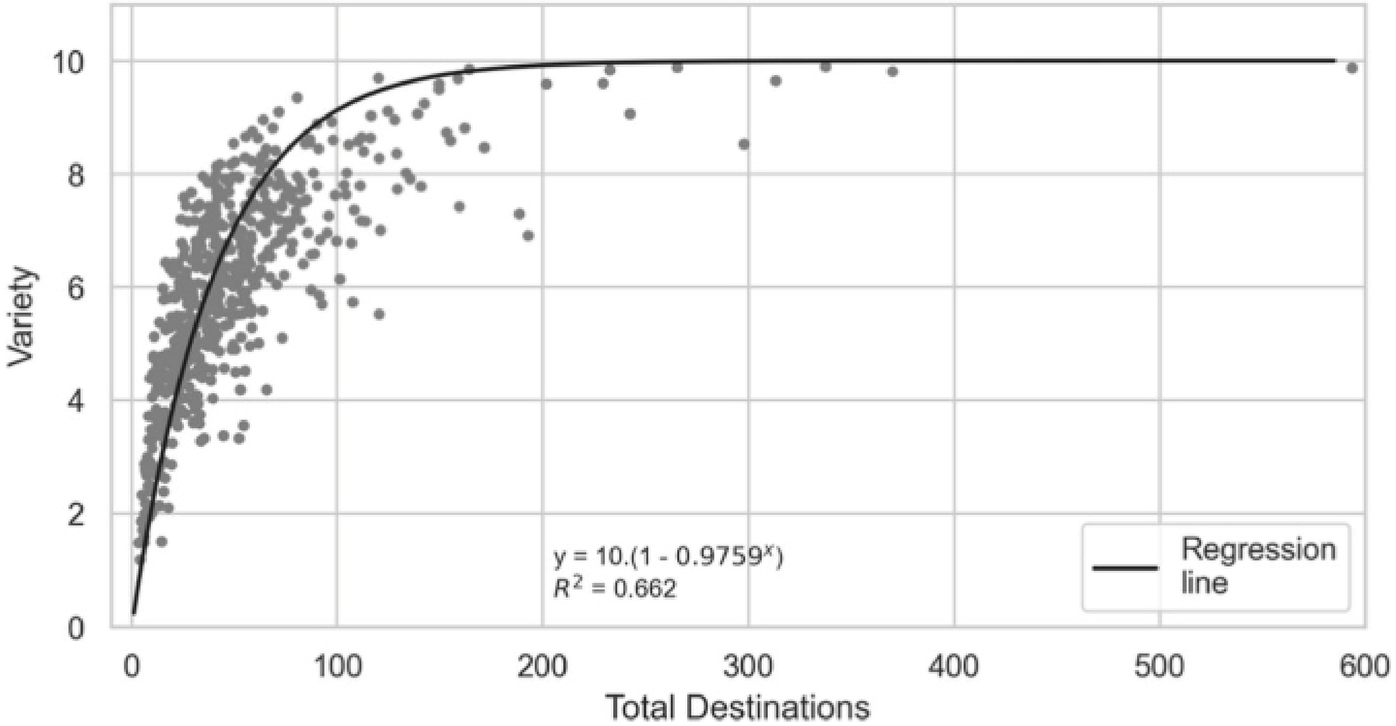


Fig. 4 Total Destinations and Variety dispersion diagram. The diagram shows the correlation of Total Destinations and Variety across 585 European cities. The fitted curve demonstrates an upward exponential decay trend.

Results

(3) Accessibility, population size and density

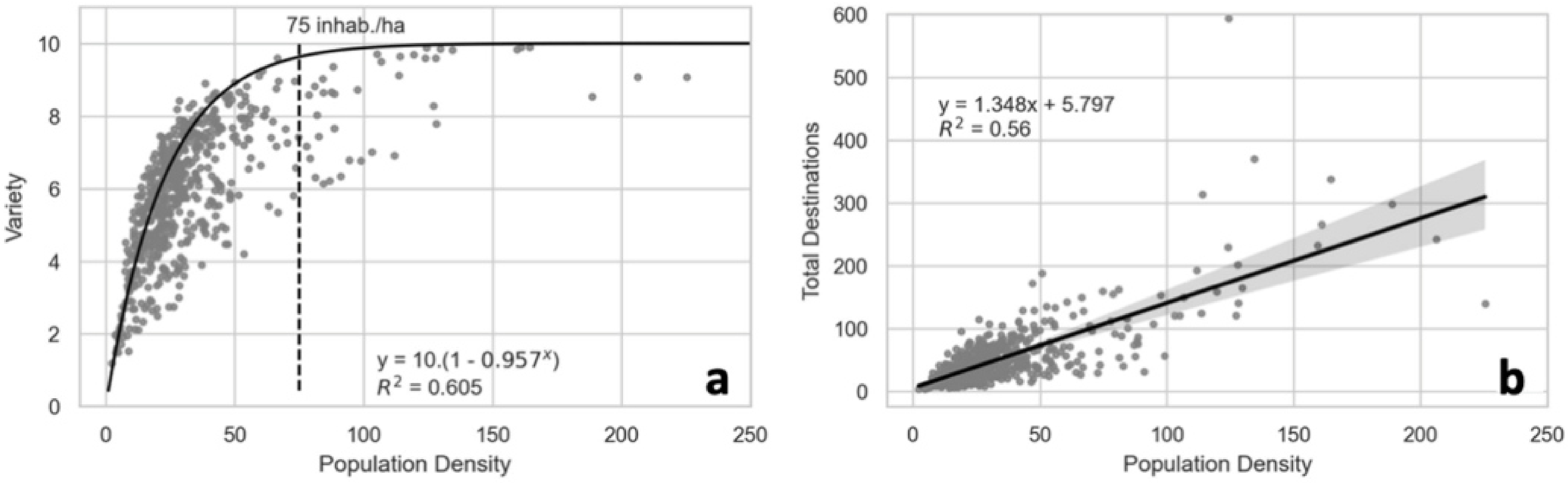


Fig. 5 Correlation between Population density and the Variety and Total Destinations values. Diagrams showing the relationship between population density and **a** Variety and **b** Total Destinations. In **a** it is possible to see the 75 inhabits./ha line indicating the point from which density increments translate into less Variety gain.

Results

(3) Accessibility, population size and density

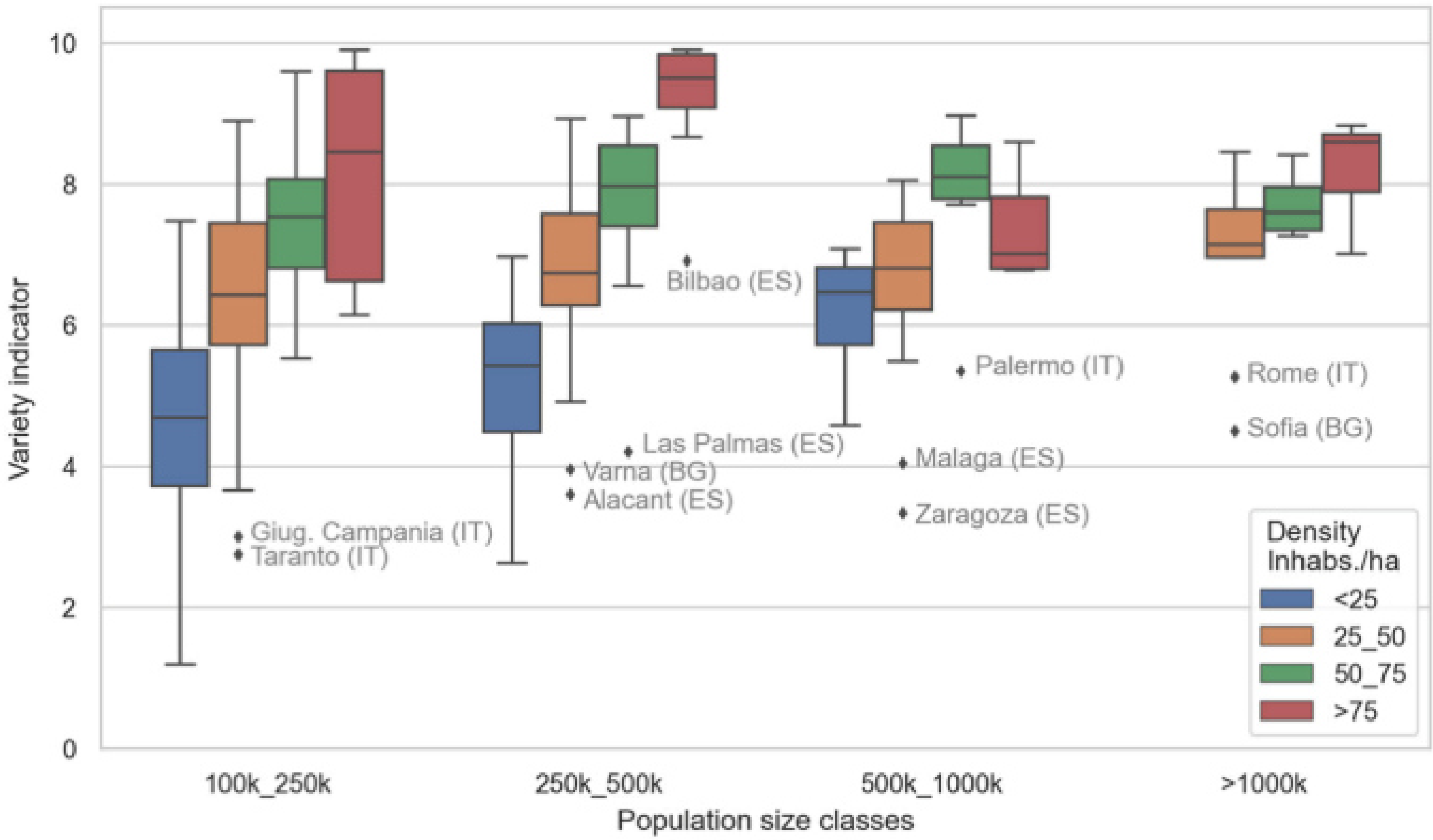


Fig. 6 Variety levels for population-size and density-level (inhabits./ha) classes of cities. The boxplot diagram shows that larger cities tend to present lower Variety variance and higher average Variance levels.

Results

(4) Accessibility Inequality

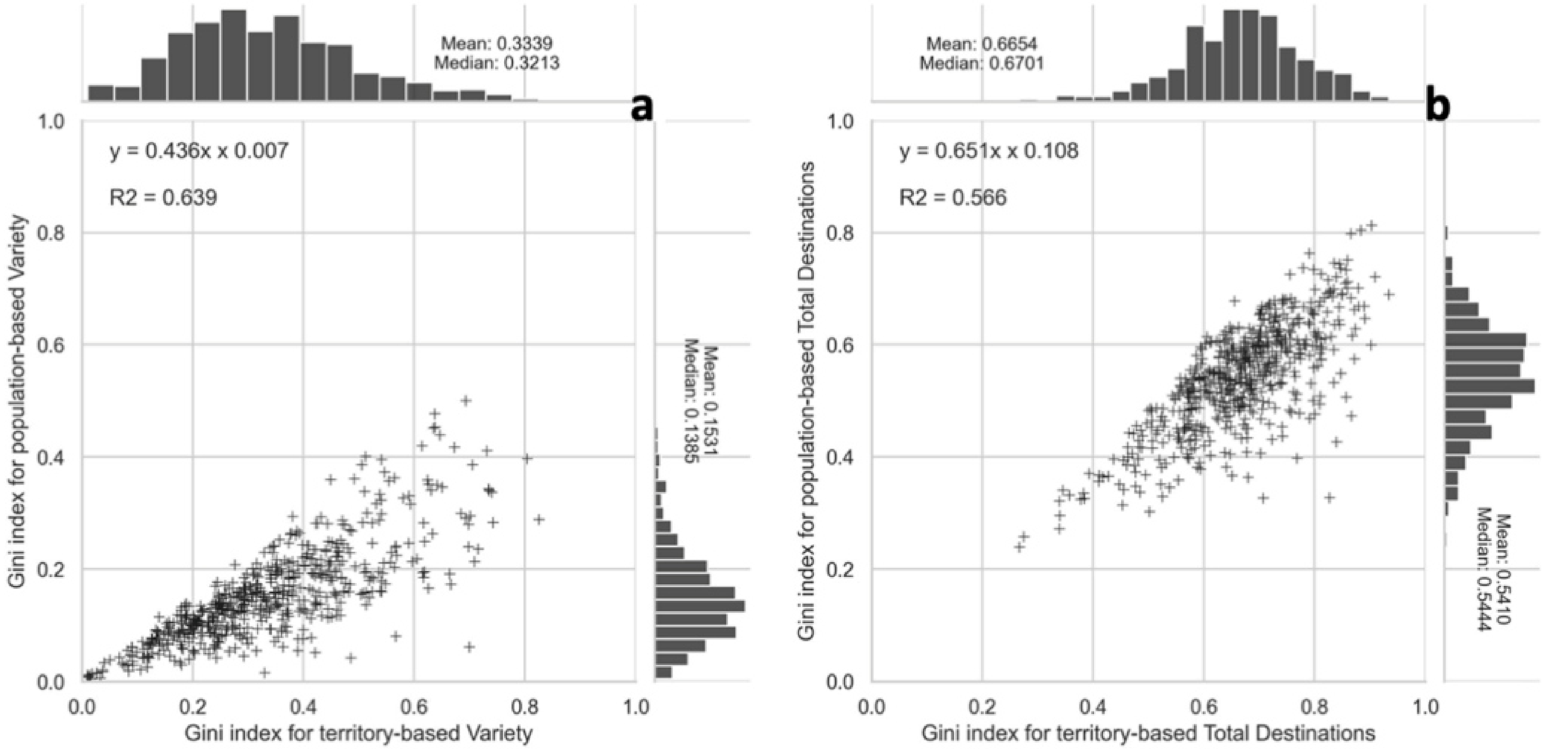


Fig. 7 Comparison between the population and territory-based inequality levels of Variety and Total Destinations. The dispersion diagrams indicate the relationship between P-Gini and T-Gini coefficients for both Variety **a** and Total Destinations **b** accessibility indicators, accompanied by the histograms for each variable.

Results

(4) Accessibility Inequality

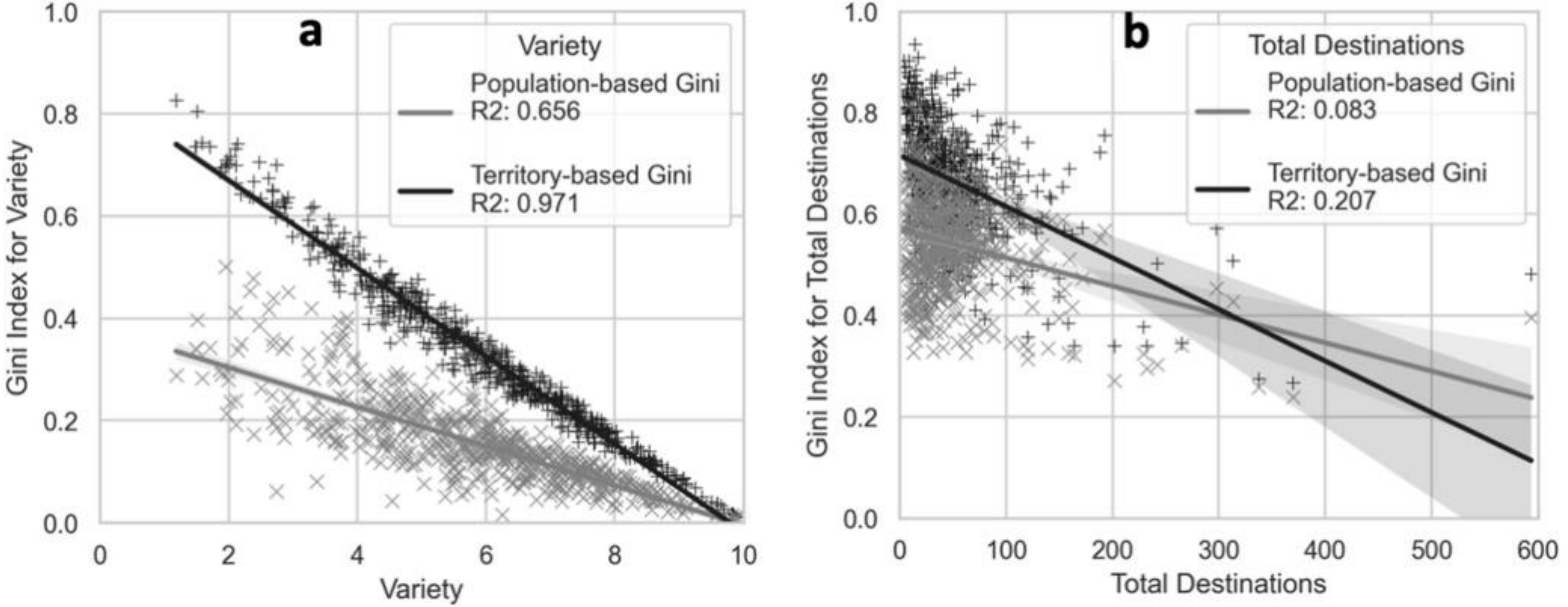


Fig. 8 How Variety and Total Destinations levels correlate to their inequality levels? Dispersion diagrams showing the relationship between territory and population-based Gini coefficients and both **a** Variety and **b** Total Destinations accessibility indicators for 585 European cities.

Results

(4) Accessibility Inequality

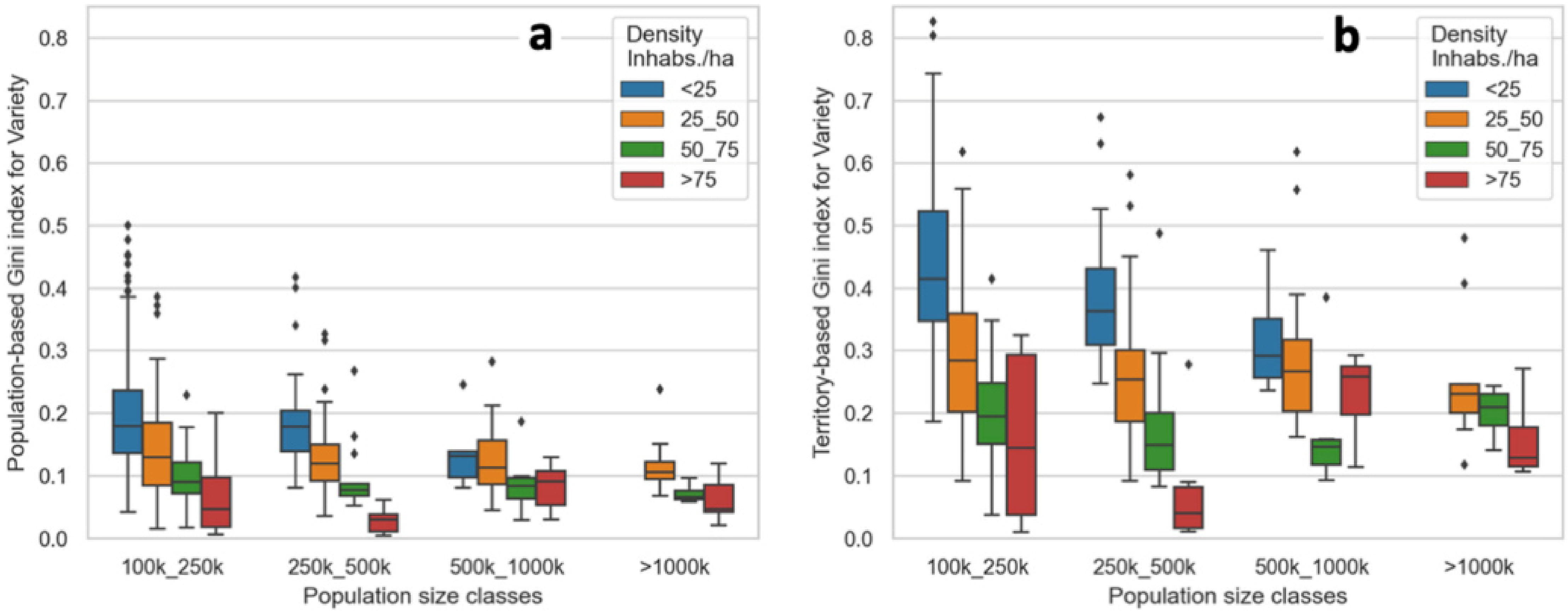


Fig. 9 Population and Territory-based inequality levels distribution for distinct city sizes and density levels. Boxplot comparison between **a** population-based and **b** territory-based Gini coefficients for Variety levels of cities with distinct density and population sizes.

Conclusion

- Pedestrian accessibility conditions are **quite diverse** in our sample of European cities
- In the absence of a normative accessibility value, computing accessibility to **total destinations is a useful way to analyse within-city differences**
  - However, classifying places as having 'good' or 'bad' accessibility is less clear
- the **Variety** indicator proved to be a useful measure of **within-city differences** and a way to compare the accessibility of **different cities**.
  - Mean values ranging from 1.2 to 9.6 (out of a maximum of 10)
- Exponential decay upward relationship between Total Destinations and Variety, suggesting **diminishing marginal returns** between them

Conclusion

- Geographically:
  - **Total Destinations** indicator tends to highlight a single hotspot in the city centre
  - **Variety** indicator reveals several polycentric patterns.
    - Even with a relatively small number of total destinations accessible by foot, there are places within cities that provide highly diverse accessibility.

Conclusion

- Both T-Gini and P-Gini differences were noticeable, with the **coefficients associated with Variety being systematically lower than those of Total Destinations**.
- The unforeseen result is that while **Variety levels are strongly associated with inequality levels, Total Destinations are not**.
  - Possible explanations:
    - activities' locational decisions follow the logic of **spatial agglomeration or clustering**,
    - Variety is affected not only by activities' locational choices but also by people's locational choices. **People try to balance out the accessibility to needed activities**.
- Overall, and for all cities, **population inequality is lower than territorial inequality**, suggesting that residential location decisions tend to alleviate inequality levels

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Accessibility inequality across Europe: a comparison of 15-minute pedestrian accessibility in cities with 100,000 or more inhabitants

David Vale [1] ✉ and André Soares Lopes [1] ✉

Active accessibility is a paramount objective of current sustainable urban development policies. Recently, the 15-minute city concept emphasized this framework by stressing proximity as a key urban feature. In this paper, we use two accessibility indicators—cumulative opportunities (total destinations) and Variety (number of different types of opportunities)—to evaluate pedestrian accessibility, using a 15-minute threshold, in a sample of European cities with 100,000 or more inhabitants, and measure within-city and between-city inequality, by calculating pseudo-Gini coefficients. Our results show not only that European cities are not 15-minute cities yet, but also that there is significant inequality within them, although less so in cities with high Variety. Our cross-city comparison found diminishing returns between both total destinations and population density and between Variety and density. Our findings suggest that European cities can increase pedestrian accessibility and reduce internal inequality by increasing the Variety of opportunities accessible by foot, along with improvements to pedestrian infrastructure.

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