Accessibility across Italy: A grid cell approach*

Vania Licio† Anna Maria Pinna‡

Abstract

This paper aims to address and discuss the measurement of within-country accessibility by computing travel times for Italy. Typically, domestic accessibility is measured at the municipal level, the smallest unit of analysis used in official national statistics; however, this territorial division may lack the granularity needed to capture specific variations within each unit. Conversely, supranational accessibility leverages finer information; however, if collected worldwide, global satellite and geocoded data may struggle with fine-grained accuracy within a country. To tackle these issues, we propose and analyze some measures of accessibility—defined by travel times to cities, transport infrastructure, and facilities at the sub-municipal level—using grid cells of five-by-five kilometers for the whole Italian territory and combining geocoded information with data from the national census and governmental offices. The measures computed in this paper offer a finer-grained quantification of accessibility, capturing differences within the same administrative level. Additionally, the grid cell approach—an analytical framework independent of political or administrative boundaries—allows for a more exogenous accessibility measurement. We use maps to visually present our findings.

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†Corresponding author. DSEA - University of Cagliari and CRENoS. Email: vaniam.licio@unica.it.

‡DSEA - University of Cagliari and CRENoS. Email: ampinna@unica.it.

In the past decade, economic and transportation literature has shown a growing interest in understanding how easily individuals can access desired destinations and the time required to reach them. Measuring and accounting for ease of access to locations at reduced travel times can be traced back to early works such as Harris (1954) and Hansen (1959), who demonstrated that areas with better accessibility tend to develop at higher densities and are more attractive than less accessible areas.

Urban economic literature has traditionally focused on accessibility and travel times at a regional level, examining how transportation systems optimize resources and achieve goals, such as increased mobility, reduced travel times, and improved connectivity. However, sub-regional analyses have become more prevalent recently. The first global map of travel times to major cities was released by the Joint Research Center in 2008, with data developed by Nelson (2008) in collaboration with the World Bank. This map accounted for factors such as geographical barriers, national borders, and the quality of transport infrastructure. Weiss et al. (2018) expanded Nelson's work by updating global travel times to cities for 2015, using a spatial resolution of one-by-one kilometer. In 2020, Weiss et al. (2020) created a global map of travel times to healthcare facilities, incorporating walking-only and motorized friction surfaces to assess geographical and infrastructural barriers. And in the same year, Christodoulou et al. (2020) constructed a dataset on urban accessibility and congestion in European cities with at least 250,000 people.

Accessibility is a multidimensional concept commonly quantified through various indices, reflecting the proximity of goods, services, and employment opportunities for individuals and firms. Travel times are the flip side of the coin: they provide essential information for discussing accessibility. Reduced travel times, driven by technological advancements, have led to increased flows of people, goods, and information, influencing urban mobility, the spatial distribution of activities, and location choices. However, assessing accessibility and travel times remains complex, as both involve a broad set of dimensions linked to numerous topics across different disciplines.

Accessibility and travel times are central to the discourse on first- and second-nature geography. First-nature factors, referring to natural features such as elevation and ruggedness, and second-nature factors, involving human-made infrastructure like roads and railways, have recently been discussed in the economic geography literature as key components for understanding accessibility dynamics and their critical role in driving regional development (Ketterer and Rodríguez-Pose, 2018).

The motivation for this study stems from the need to address the significant disparities in accessibility across various regions of Italy, which have broad implications for economic opportunities, quality of life, and social inclusion. We do it at a finer level of analysis with two aims. First, to construct novel information that can be matched with further territorial details, such as firm and individual locations. Second, to evaluate how accessibility may influence other outcomes, providing a picture of accessibility discrepancies within the areas of the same municipality.

In recent years, advancements in geospatial techniques, geocoded infrastructure data, and the availability of satellite information have improved our ability to assess accessibility as a critical component of socioeconomic development. Istat—the Italian National Institute of Statistics—released updated data on various accessibility measures for all 7,903 Italian municipalities (LAU).[1] Calculations based on these statistics provide an essential first step in understanding territorial differences. However, the level of the analysis may not capture significant variation within a unit. Conversely, the accessibility to cities computed by Weiss, Nelson, Gibson et al. (2018) at the grid cell level overcomes the municipal aggregation, offering consistent, high-resolution data worldwide, regardless of municipal or institutional boundaries. However, this global representation may obscure important national-level details.

Figure 1 makes clear the argument. We map travel times to the nearest city with at least 50,000 inhabitants for the NUTS 2 region of Sardinia at both the grid cell and municipal level, comparing averages at the five-by-five kilometer grid cell using travel times by Weiss, Nelson, Gibson et al. (2018) (A), the cost surface by Weiss, Nelson, Vargas-Ruiz et al. (2020)[2] combined with endpoints from census data (B), and exploiting data by the Italian National Institute of Statistics (C). The grid cell-level analyses (A and B) reveal a more substantial internal variation within municipalities compared to municipal-level data (C). The municipal-level statistics (C) mask significant differences, not only in geographically diverse areas, where mountainous or rural regions usually face considerably longer travel times compared to urban areas, but also within the same geographical locus. An example is the province of Oristano in western Sardinia. Despite a territory uniformly flat, some areas are more disadvantaged than others, a disparity that must be reconnected with the quality of the present infrastructure. Comparing the map generated from the raster file by Weiss, Nelson, Gibson et al. (2018) (A) with the map we created by combining the cost surface from Weiss, Nelson, Vargas-Ruiz et al. (2020) and endpoints constructed using census data (B), significant differences exist. For instance, Olbia, a municipality in northeastern Sardinia with over 60,000 inhabitants and a key reference city for neighboring municipalities is absent from map A. This suggests that while satellite data are well-suited for gaining a global perspective and allow for consistent cross-country comparisons, they may lack the granularity needed to capture specific regional variations within a country.

Our approach overcomes the limitations of supranational data and is based on the methodology we developed for map B. We decompose Italy into five-by-five kilometer grid cells[3] and combine the friction surface of land-based travel speeds constructed by Weiss, Nelson, Vargas-Ruiz et al. (2020)[4] with

1 Released data include both bilateral travel times between all Italian municipalities and data reflecting each municipality's accessibility to various key destinations.

2 Weiss, Nelson, Vargas-Ruiz et al. (2020) make available both their precomputed travel times and the cost surface used to compute them. For our computations we use the latter.

3 The choice of dividing Italy into 5x5 km grid cells is driven by computational considerations. Conducting the analyses presented in this paper on a standard computer using 1x1 km grid cells would make some calculations either infeasible or prohibitively time-consuming.

4 In the works by Weiss, Nelson, Vargas-Ruiz et al. (2020) and by Weiss, Nelson, Gibson et al. (2018), the global friction surface is used to compute travel times worldwide to the nearest healthcare facility and nearest city, respectively. The difference between the friction surfaces used in the two papers is the accuracy of roads for developing countries: the

endpoints derived primarily from Italian national sources. This produces a highly detailed analysis of travel times and accessibility within Italy, providing a finer resolution for intra-country measurements.

We examine travel times to major urban centers, ports, airports, medium-to-large railway stations, and motorway access points. The detailed data offered by this work can be merged with other location measures to study the impact of accessibility on various outcomes at the firm or individual level. By highlighting territorial disparities, this study offers policymakers actionable insights to support balanced regional development and enhance social and economic inclusion nationwide. Our findings shed light on accessibility gaps that impede equitable development, especially in rural areas, southern Italy, and the islands of Sardinia and Sicily, where infrastructure investments have historically lagged. In this context, the study underscores the importance of transport justice in ensuring equitable access to essential services such as healthcare, education, and employment, and contributes to the broader field of accessibility research, aligning with studies by Ryan et al. (2023) and Kim and Chung (2018).

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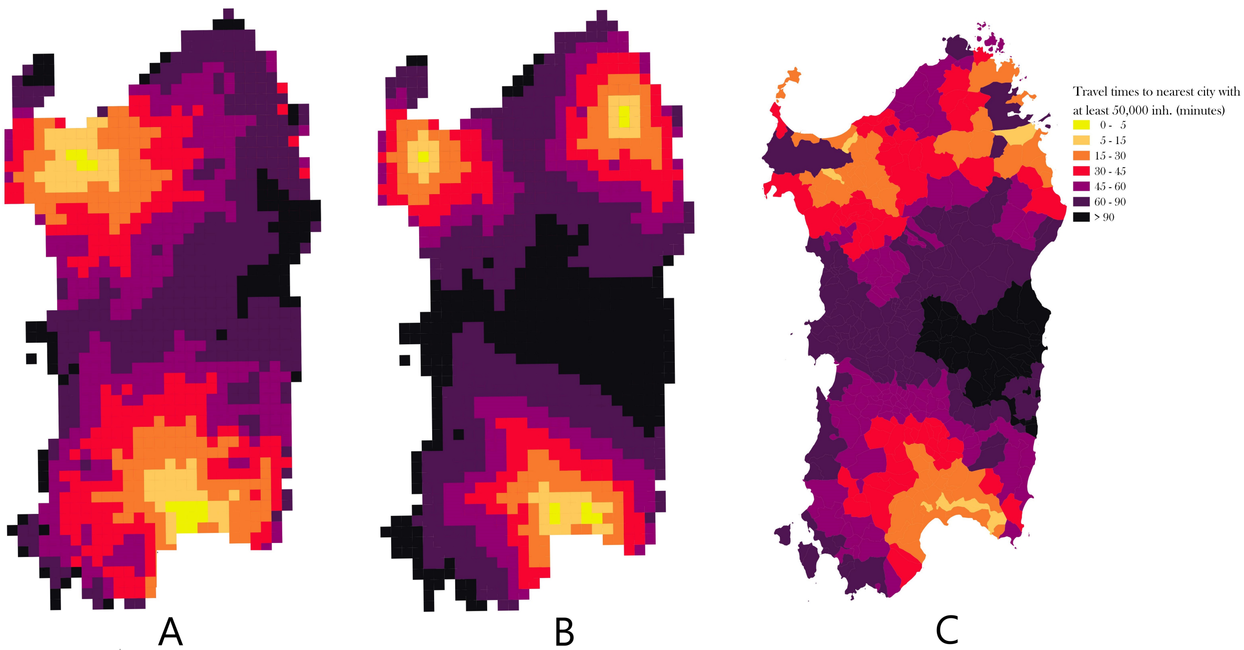
former is more detailed.

Figures and tables

Figure 1: Travel times to the nearest city of at least 50,000 inh. in 2019 (minutes): 5x5 km grid cell averages with Weiss, Nelson, Vargas-Ruiz et al. (2018) data (**A**), 5x5 km grid cell averages with Weiss, Nelson, Vargas-Ruiz et al. (2020) cost surface and our endpoints (**B**), municipalities with Istat data (**C**)



Source: Own elaborations from Weiss, Nelson, Vargas-Ruiz et al. (2018), Weiss, Nelson, Vargas-Ruiz et al. (2020), and Istat data