11th Scientific Meeting of the SIS Group
"Statistics for the Evaluation and Quality in Services"

BOOK OF SHORT PAPERS

Editors
Andrea Bucci
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STATISTICAL METHODS FOR EVALUATION AND QUALITY: TECHNIQUES, TECHNOLOGIES AND TRENDS (T^3)

EDIZIONI Il Viandante

IES 2023 - Statistical Methods for Evaluation and Quality: Techniques, Technologies and Trends (T^3)

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Book of Short papers
11th International Conference **IES 2023**
Statistical Methods for Evaluation and Quality: Techniques, Technologies and Trends (T^3)

University 'G. d'Annunzio' of Chieti-Pescara

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Preface

Statistical thinking, design and analysis play a crucial role in social life and are useful to society at large. Besides, promoting advanced methodological research is useful to facilitate the dissemination of ideas related to various fields of interest. For this purpose, experts in statistics, data analysis, data mining, statistical methods for decision making, machine learning and related methods come together to understand and analyse phenomena through data.

In line with this objective, the Statistics Group for the Evaluation and Quality of Services (SVQS; www.svqs.it) of the Italian Statistical Society (SIS) has been organizing the Innovation and Society (IeS) conference biennially since 2009, focusing on new developments and ideas in statistics applied to the evaluation and quality of public and private services, attracting national and international statisticians and data scientists. The meeting contributes to spot light on the main statistical approaches and methodologies for the evaluation of public services currently in use in different contexts, as well as to facilitate discussion on the impact of innovative statistical evaluation systems for these services, involving various economic and social policy actors.

The conference "Statistical Methods for Evaluation and Quality: Techniques, Technologies and Trends (T^3)" recorded valuable contributions that are reported in this volume. The papers underscore how the growing availability of data has tasked social and economic actors, organizations, and researchers with the management and analysis of large volumes of unstructured and heterogeneous data. In recent years, many tools for both qualitative and quantitative models have been developed to better describe and understand complex systems and their underlying behaviors, and the papers reported in this volume bear witness to this.

Techniques, technologies and trends: the study of data complexity presents the potential to provide analyses with increased frequency and timeliness, accuracy and objectivity, and to define sustainable models. Traditional quantitative methods for capturing socioeconomic data have often shown limitations in their ability to examine underlying systems, and with the three 'T' just mentioned, the outlines of future developments are starting to emerge.

The volume reports 127 contributions in the following areas:

- Advanced statistical methods for pattern recognition
- Advances in statistical learning from high-dimensional data
- Data analysis for web sources
- Distance and depth-based statistical learning methods for robust data analysis

- Economics and environment
- Education and labour
- Inequalities in the labour market
- Innovations and challenges in official statistics
- Labour market: trends, perspectives and new challenges
- Methodological and applicative contributions for evaluating sustainable development
- Methodological developments and applications for the assessment of student competencies
- Networks data analysis: new perspectives and applications
- New advanced statistical methods for data science
- Recent advances in statistical learning and data analysis
- Statistical analysis and modeling of environmental pollution data
- Statistical methods and complexity for evaluation in finance
- Statistical methods and composite indicators for healthcare
- Statistical methods and models for land monitoring with spatio-temporal data
- Statistical methods for environmental monitoring and sustainability
- Statistical methods for the analysis of university student choices and academic performance
- Statistical methods for the assessment of transport services and sustainable emissions
- Statistical methods for education and educational services
- Statistics in sports
- Tourism and territory.

The Conference event attracted many contributions as well as numerous Authors, not just from Italy but also from abroad. Over the three-day meeting, the Community has the opportunity to witness some of the state-of-the arts, new trajectories, and methodological challenges in 24 solicited sessions, 7 sessions of free contributes, two round tables - organized by Maurizio Vichi and Matilde Bini respectively - and three keynotes sessions with Ron S. Kennet of Samuel Neaman Institute of Israel, Luigi D'Ambra of Federico II University of Naples, and the former Minister Enrico Giovannini from University of Tor Vergata.

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Coordinator of the SVQS Group

Contents

Investigating the patterns of Italian internal mobility: a network analysis at provincial level

La mobilità interna italiana: un'analisi di rete a livello provinciale

Annalina Sarra, Dario D'Ingiullo, Adelia Evangelista, Eugenia Nissi, Davide Quaglione and Tonio Di Battista

Abstract This study employs network analysis to investigate internal migration patterns in Italy from 2002 to 2018. Using filtering methods, the observed dense network was reduced to its essential components. The extracted backbone's characteristics were then examined, including measures of structural balance and community detection. Our findings suggest that the majority of signed links in the network exhibit reciprocity, and that positive relationships between geographically close-by cities and their shared locations at greater distances contribute to a structural balance. Additionally, a community analysis revealed that geography play a crucial role in defining communities within the network.

Abstract *Questa ricerca utilizza l'analisi delle reti per indagare i modelli di migrazione interna in Italia dal 2002 al 2018. Utilizzando metodi di filtraggio, la fitta rete osservata è stata ridotta alle sue componenti essenziali. Le caratteristiche del backbone estratto sono state quindi esaminate, inclusi i parametri di equilibrio strutturale e la rilevazione delle comunità. I nostri risultati suggeriscono che la maggior parte dei collegamenti con segno nella rete mostrano reciprocità, e che le relazioni positive tra le città geograficamente vicine e le loro destinazioni comuni a distanze maggiori contribuiscono ad un equilibrio strutturale. Inoltre,*

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un'analisi delle comunità ha indicato che la geografia svolge un ruolo cruciale nella definizione delle comunità all'interno della rete.

Key words: Internal migration, Italy, Network analysis, Filtering methods, Community detection.

1 Introduction

Internal migration – that is the share of individuals who permanently transfer their place of residence within the national boundaries – affecting the spatial redistribution of people and their characteristics, is recognized to be an important mechanism able to influence several socio-economic outcomes [4]. Hence, investigating the structure and dynamics of the internal migrations should occupy a central stage on academic and policy debate in order to develop and put in place sound policies for a given economy. Studying internal migration patterns is crucial in countries like Italy, our area of focus, where significant territorial imbalances exist. It allows for a better understanding of the dynamics of population movements within the country's economy, highlighting areas of growth and areas that may require additional support. The literature strand on the determinants of Italian migration has demonstrated, in fact, how better socio-economic and institutional characteristics of the North induce a population redistribution towards this area, which in turn can further improve its already better structural characteristics (if these flows are endowed with a high level of education) [5]. By considering the consequences, in fact, the growing age and skill selectivity that characterizes the internal flows, contributing to spread skills and knowledge across regions, makes internal migration a crucial growth enhancing mechanism in the host economy [3, 1]. Therefore, this selectivity in migration contributes to feed a vicious circle to the detriment of the already backward regions of the *Mezzogiorno*. In this frame, an important contribution stems from an analytical tool largely adopted in several economic and non-economic fields: the network analysis. This methodology is particularly useful to provide an immediate representation of the relationships and functional linkages that exist among regions of a given economy, by combining measures of network connectivity with measures of network shape [2]. Building upon this, we extend the commonly used network analysis methods by incorporating a filtering technique that extracts both positive and negative migration links (i.e., a signed network) and by utilizing machine learning methods to analyze the low-dimensional representation of the migration system. This approach, as proposed by [7], allows for a more comprehensive analysis of the migration patterns and dynamics. In doing this, the present article makes use of a unique database that consists of bilateral migration flows among Italian regions (NUTS-3) collected by the Italian National Institute of Statistics (ISTAT) in the Migratory movements of resident population – registrations and cancellations to the registry office. The reminder of the article is structured as follows: Section 2 illus-

trates the data collection and the methodology. In Section 3 the results are presented and discussed.

2 Data and methods

2.1 Data

The bilateral migration flows among the 103 Italian provinces for the years 2002-2018 are collected by the ISTAT in the Migratory movements of resident population, registrations and cancellations to the registry office. For each year, by considering all the possible migration flows among the 103 Italian provinces, the resulting bilateral matrix of interprovincial movements is a square matrix that has a dimension of 103 x 103. Obviously, by excluding the main diagonal, which contains only zeros by definition (i.e. we do not consider the intra-provincial mobility), the total number of observations for a single year is equal to 10,506.

2.2 Methodology: Network analysis

Based on the approach outlined by [6], we implemented a four-step methodology to analyze the structure and dynamics of internal migration within Italy at the provincial level. Our first step involved constructing a directed and weighted network to model migration in-flows and out-flows between cities. Specifically, we created a distinct network for each year, in which links represented the movement of individuals from an origin city to a destination city, with the weight of each link indicating the number of people migrating. Formally, we represented the directed and weighted network as $G(V,E,W)$, where $|V|$ is the set of nodes denoted by $i, j, ...$, $|E|$ is the set of directed edges, and W is the weighted adjacency matrix. The network consisted of n nodes and m edges, with W_{ij} representing the number of migrants moving from node i to node j, and W_{ii} being equal to 0. In the second step, we aimed to extract relevant and significant information from the initial networks by simplifying and reducing them into a sparser format that preserves sufficient structural information for efficient analysis. This resulted in the creation of a meaningful signed network, denoted by $\hat{G} := (\hat{V},\hat{A},\hat{W})$, where the sparse adjacency matrix $\hat{A}$ typically only contains values of -1, 0, or 1. The sparse adjacency matrix is used to represent the links between nodes in the network, with a value of -1 indicating a negative link (an inhibitory relationship), a value of 1 indicating a positive link (an excitatory relationship), and a value of 0 indicating the absence of a link. The corresponding weight matrix, $\hat{W}$, is optional and only assigned to non-zero values in $\hat{A}$. If $\hat{A}_{ij} = 0$, then $\hat{W}_{i,j}$ is also 0, otherwise, $\hat{W}_{i,j}$ has the same sign as $\hat{A}_{i,j}$. This process involves information filtering, also known as "backbone extraction" or "network sparsifica-

tion," which entails removing unnecessary or weak links in a network to extract its most important and informative connections. Various methods, including filtering techniques, can be used to achieve this "sparsification". We utilized a recent dense network filtering method proposed by [6] in 2021 to extract both positive and negative links. This approach relies on a null model that considers the in-strength and out-strength of nodes to estimate expected link weights and identify links with significantly different weights as positive or negative. The method can extract the network's signed backbone at a desired level of sparsity, based on the statistical significance of the links (via its significance filter) or the intensity of the links (via its vigor filter). The vigor filter is a lift-based measure that ranges from -1 to 1 and can be used to determine the strength of the links. By using this method, researchers can analyze important connections in a network and gain insights into its structure and function. Our subsequent objective was to create a concise representation of nodes by eliminating irrelevant information. This involved estimating an embedding matrix $\mathbf{Z}$ with dimensions $(n \times d)$, where n is the number of nodes, d is the embedding size, and z_i represents the embedding vector of node i. Our goal was to find a relation between $f(i, j)$ and $g(z_i, zj)$, where f is a similarity function in the observed network and g is a similarity function in the latent space. We chose cosine similarity as the similarity function, given that the input data's similarity range (i.e., edge weights in the signed backbone) is between -1 and 1. To complement the analysis of the migration system using lower dimensions, we implemented established clustering methods to identify community structures in the migration networks.

3 Results and discussion

In this section, we present the results of our study on migration patterns. In terms of the total number of migrants, we record a slow but often steady decrease in the number of people who have moved. The examination of the migration flows within the original network indicates that exists a reduced number of links that possess significantly greater weights. Additionally, the distribution of node strengths is characterized by a high degree of heterogeneity, with a few cities accounting for a disproportionate volume of migration. It is worth noting that, in the case of Italy's internal migration, there are migration flows between all pairs of cities in both directions, resulting in a network that is inherently dense. This highlights the need to filter out insignificant links. To achieve this, we employed information filtering methods that took into account the network's multiscale nature, thereby enabling the extraction of a sparse backbone. After analyzing the backbone's characteristics, it becomes apparent that most signed links in the network demonstrate reciprocity, as they are reciprocated by links bearing the same sign. Even when the size of the backbone is considerably large, conflicting links are rare. We also evaluated whether the extracted network exhibits a structural balance or weak structural balance (Fig.1). Our results indicate the presence of a structural balance among the nodes in our networks, which may be attributed to positive relationships between geographically

close-by cities and their shared destinations at greater distances. Fig. 2 displays the spatial network of Italy's internal migration backbone in 2018.

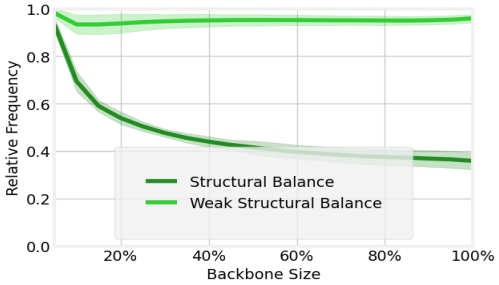

Fig. 1 Characteristics of migration backbones: structural balance

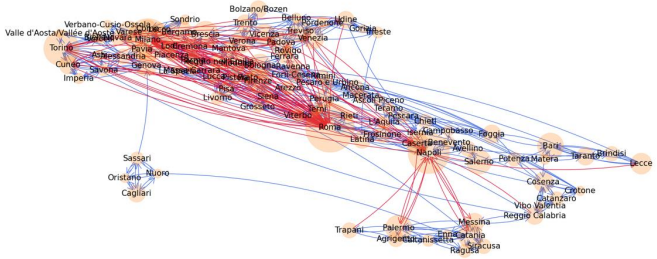

Fig. 2 Spatial network of migration backbone in 2018

Most of the positive links that extend beyond the local level in the network are oriented in a South-North direction. One possible explanation for this trend is that long-distance migrations typically occur between areas with significant economic hubs and activity centers that in Italy are located in the northern regions. We conclude our investigation with a community analysis. Figure 3 displays the results of the density-based clustering for both 2002 and 2018, using different colors for

each cluster. Our analysis indicates that geographical proximity plays a major role in defining communities. The results suggest that areas that are closer to each other tend to be clustered together, regardless of other factors such as population density or economic activity. This finding has important implications for understanding patterns of regional development and social interaction.

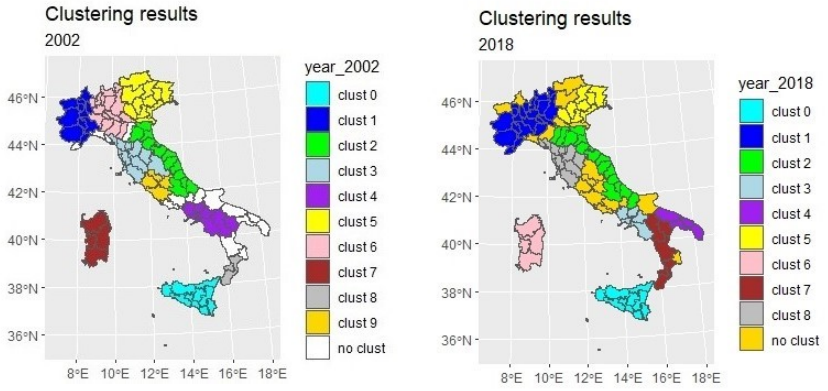

Fig. 3 Density-based clusters

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