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BOOK OF SHORT PAPERS

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

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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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Contents

An exploratory strategy for analyzing students' mobility data

Una strategia esplorativa per analizzare dati di mobilità studentesca

Ilaria Primerano and Giuseppe Giordano

Abstract This contribution deals with Italian students' decision to churn in the transition from the first to the second year of a bachelor's degree program. Based on these choices, three different churn scenarios are identified according to the decision to move towards a different university, to change degree programs, or both. Exploratory data analysis and Social Network methods are used to trace and visualize the links among universities defined considering these students' flows. The analysis is conducted considering students enrolled in universities located in the Campania region (Italy). The aim is to define an index of students' mobility flows considering their retention ability and students churn.

Abstract *Questo contributo analizza il tema della mobilità studentesca considerando la decisione degli studenti di trasferirsi nel passaggio dal primo al secondo anno di un corso di laurea triennale (churn risk). Da queste decisioni emergono diversi scenari di churn che dipendono dalla scelta di iscriversi in un'altra università, cambiare corso di laurea o entrambi. La Social Network Analysis permette di tracciare e visualizzare i legami tra le università definiti in base a questo specifico tipo di mobilità. L'analisi è stata condotta considerando gli studenti iscritti alle università situate nella regione Campania (Italia). L'obiettivo è definire un indice dei flussi degli studenti basato sulle decisioni di trasferimento e la capacità di ritenzione delle università.*

Key words: Churn risk, Correspondence Analysis, Directed Graphs, Origin Destination Matrix, Weighted Network

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1 Introduction

Tracing the main patterns of students mobility in higher education is one of the key issues in territorial policy. In fact, both the entire university and territorial governance systems are interested in understanding the factors behind students' decisions and outcomes with respect to university and degree program choice, and also inherent in post-enrollment choices such as inter-universities and/or degree program re-locations, and dropping out.

There are many factors that influence students' individual choices referred to the transition either from high school to bachelor's degree (first level mobility) or from bachelor's degree to master's degree (second level mobility). Sometime, these choices could lead to drop or churn out from the university system also in year-to-year transitions.

In literature, several studies have analyzed different aspects related to student mobility. Some scholars have dealt with outlining the typical patterns of student mobility in Italy, identifying the main trajectory from North to South [1, 2]. Others have focused on the definition of university attractiveness indices based on students flows among universities and territories [3, 4], also trying to highlight the push and pull factors behind the Italian students choices [5, 6]. Despite Universities implemented several measures to improve students' retention, some studies have identified important risk factors in university dropout [7, 8] and churn decisions [9, 10].

Moving from this framework, in this contribution we focus on students' churn decisions in the transition from the first to the second year of the Bachelor's degree program, defined on the bases of their choice to change disciplinary field and/or to move from the university of first enrolment. Looking at this churn decisions, three different settings could be observed: i) change Bachelor's degree program (i.e., moving from a Bachelor's degree program of one university to another Bachelor's degree program of the same university); ii) change university (i.e., moving from a Bachelor's degree program of one university to the same Bachelor's degree program in another university); and iii) change Bachelor's degree program and university (i.e., moving from a Bachelor's degree program of one university to another Bachelor's degree program in another university). Moreover, all these kinds of churn could be observed in Bachelor's, Master's and single-cycle degree programs, for all year-to-year transitions.

This contribution aims to define a quantitative measure that characterizes the flows between pairs of universities arising from students' choices. The use of Factorial Methods and Social Network Analysis allow to visualize the connections among universities according to students' flows. Based on a previous study [11], the proposed index weights a network characterizing student churn activity accounting for both the size of the university considered as a proxy of retention, and flows direction based on churning choices.

2 The churn propensity index

In this contribution we introduce the definition of a churn propensity index based on students' mobility flows among universities. We rely upon administrative data on the Italian University students collected from MOBYSU.IT database[1].

The analysis is conducted considering only students enrolled in a Bachelor's degree program. We consider only freshmen in the cohort 2018-2019 enrolled for the first time in a university who decide to churn in the transition from the first to the second year of their Bachelor's degree program. At this stage, all the disciplinary fields of the Bachelor's program are jointly considered.

Data are organized into a contingency table that considers on the rows the universities of enrollment (origin) and on the columns the universities (destination) chosen by students who changed university after the first year. In the scope of Social Network Analysis [12], this matrix can be seen as an origin-destination adjacency matrix. Its entries are interpreted as flows of students among universities. Consequently, when reading flows by rows, we refer to churning out students; while reading flows by columns, we refer to incoming students.

Let us notice that the sum of all the off-diagonal elements accounts for the total amount of students who decide to churn; while the sum of the elements on the main diagonal accounts for the total amount of stayers. Specifically, for each university, the corresponding element on the main diagonal is a proxy of its retention capability, the off-diagonal elements summed-up by each row gives the number of churning students as a degree of university disenrollment risk; while the off-diagonal elements summed-up by each column gives the number of incoming students as a degree of university attractiveness. In the language of social network analysis, these two quantities correspond to the nodes' out-degree and in-degree.

From this adjacency matrix, we obtain a one-mode, directed and weighted network representing the flows of churning students, where the nodes are the universities, and the edges weight depend on the occurrences of students that decide to churn. Thus, the origin nodes are the universities selected by students as first choice at the time of enrollment (i.e., in 2018), while the destination nodes are the universities choice after the churn decision (i.e, in 2019).

Thus, we propose a global churn propensity index as the ratio between the total number of churning students and the total number of stayers. This index can be specialized for each university as the ratio between the sum of the off-diagonal elements in a row and the corresponding diagonal element. Furthermore, we can specify this index also for each pair of universities as the ratio between each cell and the corresponding diagonal element in a row.

[1] Data drawn from the Italian 'Anagrafe Nazionale della Formazione Superiore' has been processed according to the research project 'From high school to the job market: analysis of the university careers and the university North-South mobility' carried out by the University of Palermo (head of the research program), the Italian 'Ministero Università e Ricerca', and INVALSI

2.1 Some evidences from the Campania Region

In this contribution, we focus on students enrolled in a Bachelor's degree program at the universities located in the Campania region, in Italy. The seven universities in Campania, according to their main geographical province of reference, are: University of Naples Federico II, University of Naples "L'Orientale", Suor Orsola Benincasa University of Naples, and Parthenope University in provincce of Naples, University of Campania Luigi Vanvitelli in province of Caserta, University of Sannio in province of Benevento; and University of Salerno in province of Salerno. Moreover, we do not consider students enrolled in telematic universities, single-cycle and health professions degree programs.

The adjacency matrix holding the seven universities in the region counts the flows of 18,894 students enrolled in the academic year 2018-2019, of whom the 96% are stayers in the next year (a.y. 2019-2020). Only 4% of the students in this cohort churned after the first year, moving from the university of origin in 2018 toward a different university in 2019, regardless the disciplinary field.

We compute the churn propensity indices introduced in section 2 for all the university in the Campania region, for each single university, and for all possible pairs of universities. In the period under analysis, the global churn propensity index is equal to 4.18%, and it confirms a fairly low global propensity to churn. However, some differences emerge among the seven universities. Looking at the churn propensity indices computed for each university, the lower value is observed for the University of Salerno (1.8%), while the University of Sannio (12.5%) shows the higher one. Instead, by considering the indices computed for each pair of universities, relevant values are observed for the University of Sannio towards the universities of Salerno (4.3%), Naples Federico II (4.1%), and Vanvitelli (4.1%). Moreover, the highest churn values are observed from all universities in Campania towards the University of Naples Federico II; and from this latter towards Vanvitelli (2.2%) and Parthenope (1.3%) universities.

In the graph in Figure 1 (left side), both the churn flows and the role of each university are showed as a network; the size of the node-university is proportional to its churn propensity index, while the width of the edges depends on the occurrences of students flows linking pairs of universities

Furthermore, on the right side of Figure 1 there is the Biplot of the Correspondence Analysis computed for the matrix holding the churn propensity indices for all pairs of universities. Here, the proximity among origin universities (blue) shows similar churning out profiles and are displayed as barycenters of the universities of destination (red).

In conclusion, the graph representation reveals the central role of the University of Sannio in terms of churning students towards other universities (disenrollment risk); and the central position of the University of Naples Federico II who receives students from all the other universities (attractiveness). The important role of the University of Naples Federico II appears evident also in the biplot of the Correspondence Analysis, for both its role of origin and destination of the flows. In fact, in the first quadrant, the central position of the University of Naples Federico II (blue) can

be seen among the universities chosen by its churning students (Parthenope, Vanvitelli, Salerno and Orientale universities). While, in the third quadrant, we note the proximity between all the other universities in Campania whose students move towards the University of Naples Federico II (red) to continue their academic studies.

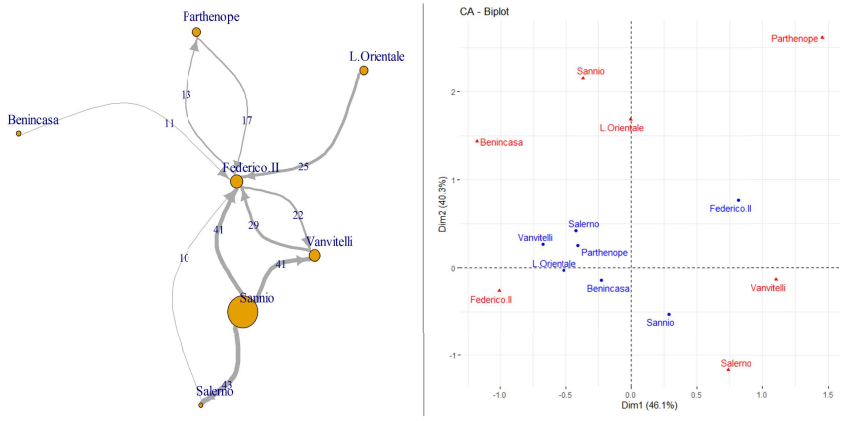

Fig. 1 Graphical representation of the churn-retention propensity index among the seven universities in the Campania region. Left side: network of churning students flows. Right side: Biplot of Correspondence Analysis of the churn propensity index.

3 Concluding remarks

This contribution proposes an exploratory strategy of analysis based on a numerical measure, a visual tool and a graph reading to discover university roles and students attitude to churn out from university of enrollment in the transition from the first to the second year of the Bachelor's degree program. Specifically, we propose a quantitative measure of university churn propensity based on students individual choices, defined at different levels of analysis, which allows us to identify the most relevant paths among universities according to students outgoing flows. The proposed approach considers a relative measure of churn propensity that take into account the retention capability of each university. It is assumed that churning flows are more politically relevant in those situation where the retention capability is low with respect to the whole amount of enrolled students. We presented a case study on the propensity to churn of students enrolled in universities in the Campania region in order to show the applicability of the proposed indices. Our analysis highlights some differences between universities located in the same territory, made even more evident by the proposed graphical representations. On the one hand, the network highlights the central position of the universities that receive the largest number of students who decided to churn, while the presence of many students leaving the origin universities is rendered by the size of the node-university. On the other hand,

the biplot of the Correspondence Analysis, allows us to identify the universities with the most similar profiles, as well as showing the central position of the origin universities compared to the destination ones.

The churn propensity index can be further specified by considering, for example, students flows occurring within the same university, or among universities located into different territorial aggregations, and/or the flows within and between different degree programs, grouped according to the ISCED-F classification. It can also be taken into account in analyzing the attractiveness of the universities by considering the enrollments of churning students. Therefore, the attractiveness of the degree programs offered and the areas in which they are geographically located could also be analyzed. In general, it is best suited in all situation where the retention capability are relatively different with respect to the size (number of students enrolled) of the universities.

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