A PROTOTYPE OF A VISUALIZATION SYSTEM TO EXPLOIT DATA ON THE POPULATION AGEING IN ITALIAN URBAN CONTEXTS [1]

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Abstract. There is a strong request to improve the easy of interpretation of the official statistic information. The request is backed by a number of international organizations and is intended to the advantage of decision makers, as well as researchers and non-specialist users. Modern tool for graphical and geographical data visualization offer resources to implement systems suited for the scope. The aim of this work is to perform a comparative analysis between different technological platforms, and to find an effective trade-off between the completeness of the traditional, official statistics and the immediate awareness of a phenomenon given by the graphical and geographical data visualization technologies. The study is performed using two dashboard prototypes implemented with two benchmark platforms: *Tableau* and *ArcGIS Dashboards*. Prototypes consist of the very same graphical objects and share a similar layout, however showing a different look and feel, and cover complementary aspects of the statistic information. Both have been extensively tested and proved effective in giving an immediate and consistent comprehension of the phenomenon on study.

1. Introduction

International recommendations on communication and dissemination strategies underline the importance of ensuring and extending accessibility to data produced by official statistics and promoting an informed use of data for correct interpretation and analysis of phenomena (Eurostat, 2021a; Unece, 2021; Oecd, 2021). In this context, the use of data visualization tools is essential to improve the dissemination and promote statistics, facilitating their use by policy makers, researchers and non-specialist users.

Advances in the data visualization topic has been firstly explored and driven by research efforts in Business Intelligence (Rouhani (2012)), with the aim of

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improving comprehension and efficiency of the business processes; see for example Dresner (2007), Eigner (2013), Kumar (2017). More in general, Ward *et al*. (2015), Sadiku *et al.* (2016), Qi *et al.* (2020), trace the lines of the field of data visualization and discuss methodologies and techniques. Diamond *et al.* (2017), Chapman (2018), Furmanova *et al.* (2020), provide a comparison among state of the art visualizations tools, including Tableau (Salesforce, 2023), Microsoft Power BI (Microsoft, 2023), Google Charts (Google, 2023), Infogram (Infogram, 2023), to limit the list to those with geographical mapping support ad whose usage does not require accurate programming skills. Müller (2003) is indeed devoted to time-series data representations. All of the cited tools are illustrated and assessed, and examples of their use are shown. Srivastava (2023) extends the discussion to various domains, such as business, social sciences, humanities, sports, environmental sciences, and healthcare, while Grainger *et al.* (2016) and Bujack (2020) analyse the visualization of environmental science data. Given the nature of such data, geographical representation is an essential asset; moreover, a particular attention is devoted to the fact that some of the involved actors could be outside the scientific community, so stressing the search of effectiveness and easy of comprehension for the discussed approaches. An increasing number of dashboards showing very effective and interactive data visualizations have been published in the web. Restricting the scope to demography and healthcare, maybe the most popular is the ‘Covid-19 Dashboard’ by the Johns Hopkins University reviewed by Kelly (2020), and developed with ArcGIS Dashboards (Esri, 2023). Other valuable efforts are ‘Age Structure’ by Ritchie *et al.* (2019), built with dedicated owner software; ‘Ageing and Health in the Americas’ by PAHO (2019), on Tableau platform; and ‘Interactive map generator’ by Eurostat (2021b), developed with dedicated software which requires IT skills to be reused. The idea of designing a data visualization tool stems from a previous work, in which an analysis was developed on the profiles of metropolitan cities (Istat, 2023). The main characteristics, diversities and common factors of these territories were identified by means of a set of indicators including some socio-demographic ones, so making it possible to measure ageing degree for populations residing in urban contexts. This set of indicators represents the basis on which he dashboard prototypes have been built. Indeed, the demographic trends of ageing are a global phenomenon, and Italy is one of the "oldest" countries in the world. Since the 1970s, demographic analysis has paid attention to the social and economic consequences of this phenomenon (Golini, 1997). This paper consists in a comparative study between geo-statistical tools for visualizing and reading data applied to the analysis of ageing in metropolitan cities through a selection of the aforementioned socio-demographic indicators. The study is carried out on two prototypes of dashboards developed with two different technologies for graphical and geographical data representation. In light of the tools comparisons discussed in the cited references, and driven by the geographical nature of our data, and finally aiming at easy-to-understand and self-consistent representations, we choose two state of the art platforms: Tableau and ArcGIS Dashboards. Prototypes are not yet publicly accessible since final evaluation and validation is still underway. The aim is not to make a ranking of the different approaches, rather to find an effective trade-off between the completeness and precision of the traditional statistical information, and the immediate awareness allowed by the graphical data fusion and integration supported by the geo-statistical tools. The remainder of the paper is structured as follows: section 2 (Methods) is devoted to explaining the approach and to detail the layout and features of the two prototypes; section 3 (Results) outlines the results of the comparison between the dashboards and the technologies involved and assesses the general fulfilment of the targets; and section 4 (Summary) is an overall recap of this study.

2. Methods

The comparative analysis is conducted, experimentally, by comparing two different technologies for viewing statistical information, namely and ArcGIS Dashboards. They are exploited to realize systems for the representation of data that facilitate the process of knowledge and interpretation of phenomena, featuring:

- interactive visualizations that allow the exploration and reading of data, through the creation of customized graphic and cartographic objects, facilitating comparisons in the territorial domains considered;
- georeferenced statistical information storage and management systems, which allow the integration of traditional and spatial statistical analysis.

More in detail, the two mentioned technologies are leveraged to implement two different prototypes of dashboards for the visualization and integration of the statistical information. Considering the different look and feel of the two platforms, as well as their different data management features, the prototypes are designed from the beginning with two different targets:

- ArcGIS dashboard: analysis of the various aspects of a phenomenon, showing as many information as possible about it;
- Tableau dashboard: in-depth analysis of a selected, single aspect of a phenomenon, showing all its structural and territorial details.

The territorial domain used for experimentation are the 14 metropolitan cities (hence CM) in their territorial articulation in urban centres and urban belts. Statistical data consists in a selection of 33 socio-demographic indicators on the structure and dynamics of the population (Istat, 2023).

The aim of this study is to find an effective trade-off between the completeness of the traditional statistical information, represented by tabular data organized in structured databases, and the instant data visualization and integration allowed by the graphical and geographical representation tools.

2.1. Overview

Both dashboards are one-page sized web applications, and only two graphical objects are used to represent statistical information: cartograms and histograms. This facilitates a fair comparison between the prototypes, as well as boosts the expected effect of immediate data integration and representation.

Underlying data, as well as a short guide, are available for download in excel and pdf format, and are accessible by means of web links.

Software versions are: ArcGIS Pro 2.8.0 (Maps creation and editing); ArcGIS Enterprise 10.9.1 (Dashboard creation and editing); Tableau Public 2022.3 (Dashboard creation and editing).

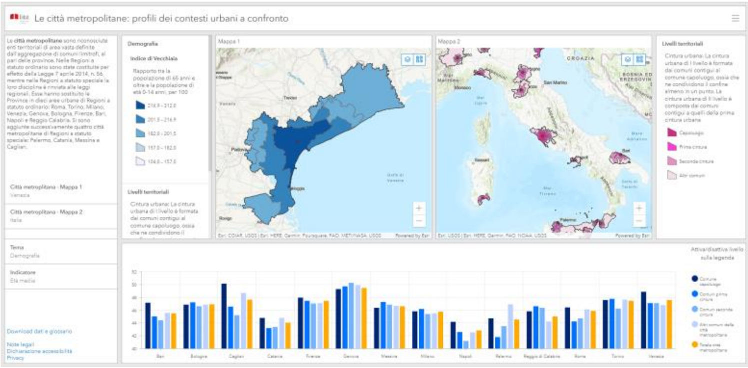
2.2. ArcGIS Dashboard

The design target of the ArcGIS dashboard is to analyse various, independent aspects of the phenomenon on study by showing simultaneously many information about it. Since all the aspects shown are virtually independent, they have the same relevance and contribute together to give to the user a complete and immediate awareness of the subject. For this reason, there is not a definite sequence of interactions, or a pattern, in the use of the dashboard.

It consists of two different cartograms on the top, based on the very same object, an *ArcGIS map* (Esri, 2019); and a histogram on the bottom. In addition, on the left side there is a short description and historical summary of the Italian CM, and a set of selectors to filter both the territory on the maps, and the indicators in the histogram. For an overview of the dashboard, see Figure 1.

Each of the cartograms shows a distinct pair of indicator and territorial detail. Also reported, on the side of the cartograms, is a short definition of the selected indicator, and a legend showing the range of its values classified in quintiles.

Figure 1 – *ArcGIS dashboard prototype.*

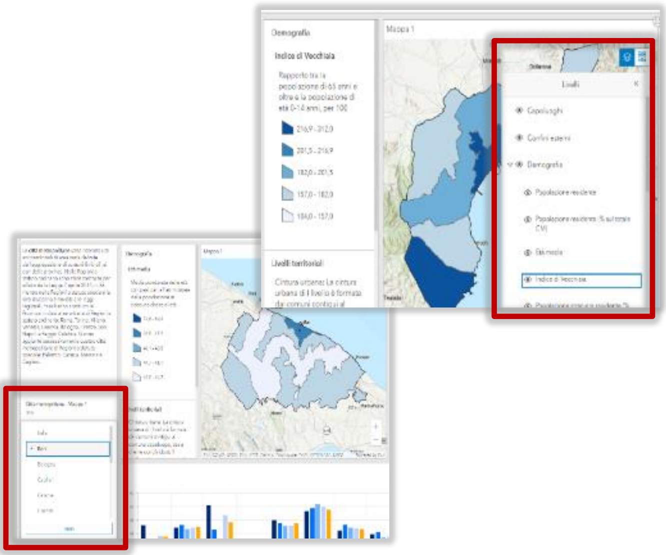


General layout.

The territorial detail, i.e. the metropolitan city, can be chosen by means of the selectors in the left side panel, see Figure 2; the default value is Italy with the full set of 14 CM. Details on the map include the urban centres and belts articulation.

The indicator to be shown is selected directly in the cartogram by clicking the *layers* icon, see Figure 2.

Figure 2 – *Selections on the map.*



Top-right: the list of the available indicators is accessible by the layers icon on the map. Clicking the eye on the left of each indicator toggles visible/not visible; only the top visible indicator is shown on the map.

Bottom-left: territorial detail is selected by means of the left side panel selectors.

Indicators are grouped by subject: demography, health, labour, and others. Each indicator is a *map layer* (Esri, 2023) that can be toggled visible or not; as per the GIS[2] tools standards and conventions, only the top visible layer is shown on the map.

By clicking a point in the map, a pop-up shows the punctual value of the indicator for that territorial detail.

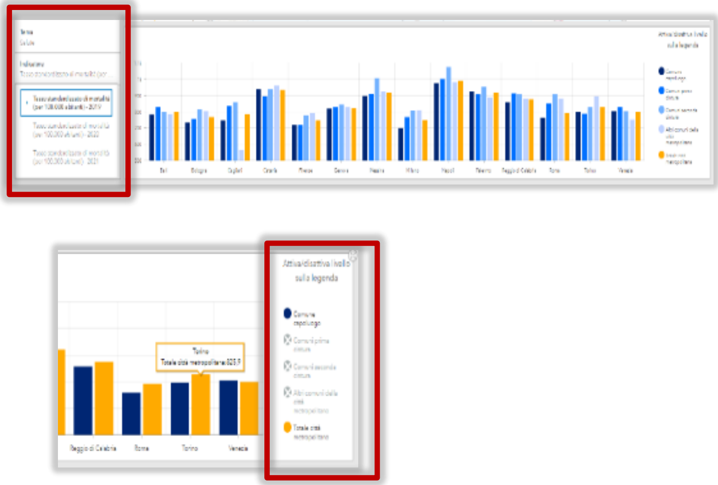
The presence of two cartograms supports the possibility of comparing, at a glance, the same indicator in two different CM; or two different indicators in the same territory; or whichever combination of (indicator, territory) pairs.

The histogram is leveraged to perform a simultaneous comparison between the 14 CM.

In this case, the indicator is chosen by means of the selectors on the left side panels, which filters them with respect to the subject they are grouped by: demography, health, labour, and others. Territorial structure of urban cities and belts is customizable by clicking the legend icons on the map, toggling visible or not the related detail, see Figure 3. Note that in the histogram the option "Total CM" is available, showing the value for the entire CM. This value cannot be visualized in the maps, due to aggregative structure of the belt levels.

Punctual value of the columns are available via pop-up, which activates on mouse moving.

Figure 3 – *Histogram.*



Top: the list of the available indicators is accessible by the left side panel selectors.
Bottom: clicking the icons in the legend toggles the related detail visible or not visible.

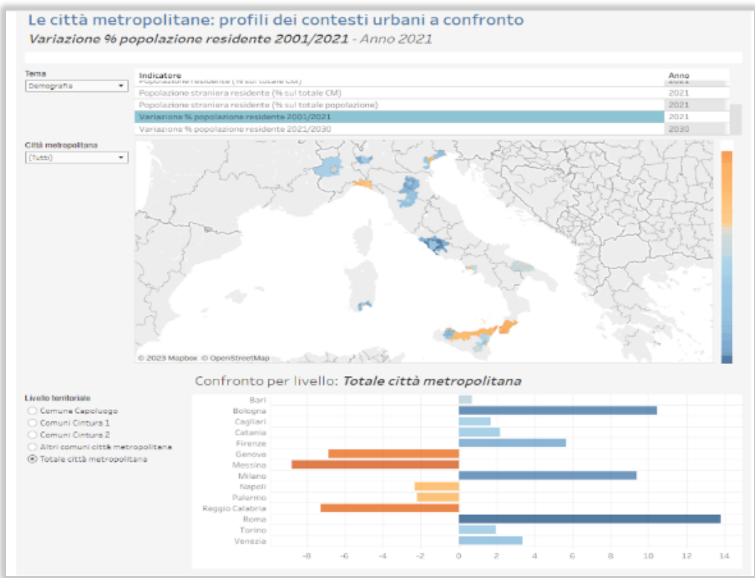
[2] Geographic Information System

2.3. Tableau

The rationale of the Tableau prototype is to carry out an in-depth analysis of a single, selectable aspect of the phenomenon on study. The whole page is therefore *indicator-driven*, and the choice of the indicator on top of the dashboard leads the interpretation of the whole dashboard. This means that there is pattern in the visualization: a sequence of interactions moving from the top to the bottom of the dashboard.

The general layout consists of a set of selectors on the top, which allows the choice of the indicator, filtered by the subject. Then there is a cartogram in the middle, and a histogram on the bottom. A view of the general layout of the dashboard is in Figure 4. All the graphical and interactive objects are conceptually identical to the ones employed in ArcGIS Dashboard prototype, although they have a different look and feel.

Figure 4 – *Tableau prototype - General layout*



As said, the main interaction is the selection of the indicator on top. Once selected, the particular aspect it describes is represented in both the cartogram and the histogram.

The geographical distribution is portrayed in the cartogram, or map. The territorial detail, i.e. the specific CM, can be selected by means of the selector on the left of the map itself. Default visualization is the map of Italy with the 14 CM. The territorial structure in urban cities and belts is also shown, as well as a legend in the right; the legend rescales to cover the values represented in the geographical detail (i.e., the CM) of the map.

In the histogram the indicator is represented simultaneously for all the 14 CM; by the options button on the left it is possible to choose one belt aggregation, or the urban cities, or the aggregate value for the entire area of the CM. In this case, differently from the ArcGIS prototype, the choice is exclusive and one only level detail can be selected.

On both map and histogram a pop-up shows the detailed information on mouse moving on it.

3. Results

Analysis of the results after an extensive session of tests on both dashboard prototypes proofs that they allow an integrated reading of the data through thematic and territorial representations of a selection of indicators.

The design choices taken in the planning phase proven crucial in obtaining the expected trade-off between completeness and instant comprehension of the phenomenon on study. In particular, the one-page layout and the use of only a limited number of graphical objects (namely cartograms and histograms) stresses the search for the ease of use and the immediacy of the information presented. On the other side, the general awareness of the phenomenon is granted by the accurate choice of the set of indicators, which covers the full spectrum of its aspects. Also to support the ease of understanding, only the last available versions of the indicators are employed; as a consequence time-series analysis, even if possible, is not supported here, and is considered out of the scope of the present study. The same project specifications prevented us to build more structured and 'verbose' prototypes such as the sites cited in the Introduction, see section 1. In those cases, priority is given to the completeness of information and the variety of data visualization tools; the loss is on the side of instant comprehension of the phenomenon.

The implementation and the comparative testing of the two prototypes highlights the different "look and feel" of the two technologies used:

- *ArcGIS* - It is the standard *de-facto* of Geographic Information Systems. As such, it requires the user to be aware of the usual GIS interaction standards (i.e. selection of the active layer in the map, see Figure 2). It allows implementing dashboards that are, essentially, built around one (or more) cartogram, and in this case implementation is straightforward and spatial features can be easily filtered with selectors. However, the set of available graphical objects is limited, and interaction between them and with the cartograms is troublesome and not always possible.

- *Tableau* - A much more versatile platform, it emphasizes flexibility and ability to link data together. It makes available a plethora of graphic objects for data visualization, and it virtually enables a complete integration between them: each object can filter (and can be filtered by) any other object in the dashboard.

The prototypes are designed from the beginning to leverage these different features. The ArcGIS dashboard has the target of analyzing the various, possibly independent, aspects of the phenomenon, showing as many information as possible about it. On the other side the Tableau dashboard consists in an in-depth analysis of a selectable, single aspect of the phenomenon, integrating the information and showing all its structural and territorial details. Although based on the very same conceptual objects for visualization, and showing an overall similar layout, the two prototypes present a complementarity of the information.

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