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Assessing the sub-urban frailties: The case of Florence

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1. Introduction

In an era marked by rapid urbanization and societal transformations, the intricate interaction between socio-economic and demographic factors has become a central concern for researchers, policymakers, and urban planners alike. In such a context, understanding the socio-economic dynamics within an area becomes essential for its sustainable development and effective governance.

The city of Florence is not exempt from the forces of change sweeping across the global landscape and this evolution has brought forth complex challenges that warrant meticulous analysis and strategic intervention. Even within a small territory, such as the municipality of Florence, we can study the heterogeneity in the living conditions of inhabitants. A pivotal and currently widely adopted approach, to understanding and addressing the nuanced intricacies of suburban areas' fragility is through the construction and assessment of a socio-economic and demographic fragility index at the suburban level.

In this paper, with the aim of quantifying and qualifying the multifaceted vulnerabilities embedded within the suburban areas of Florence, an index of such kind is suggested. By amalgamating an array of socio-economic and demographic indicators, this index unveils underlying patterns, identifies potential risk factors, and sheds light on the fragility thresholds that may undermine the sustainable development and well-being of these suburban communities. Our aim is to provide a comprehensive understanding of the complex web of factors contributing to fragility, offering valuable insights that can inform targeted policies and interventions. Through this exploration, we seek to contribute not only to the scholarly discourse on urban studies and statistics but also to the practical efforts aimed at enhancing the resilience and prosperity of Florence's suburban areas.

2. Suburban Florentine fragilites

One of the main targets of public policy is to contrast social frailties. Providing tools useful for this purpose is a developing area in social statistics and public policy areas, see Saisana and Philippas (2012) and Khan (1991). The investigation and evaluation of social vulnerabilities necessitate a rigorous examination and quantification of them. In recent years, a substantial body of research has emerged, focusing on the measurement of these intricate concepts and leading to the development of a variety of composite indicators.

Composite indicators serve as tools that amalgamate a collection of elementary indicators into a cohesive measure of complex phenomena, exemplified by metrics such as the Human Development Index (HDI) or the Environmental Performance Index (EPI). For a comprehensive understanding of the construction of synthetic indicators, a valuable resource is OECD et al. (2008). Additionally, an insightful review of existing literature, emphasizing the primary objectives of indicator construction and the attendant challenges, can be found in Greco et al. (2019). The principal aim of a synthetic indicator is to faithfully encapsulate the information inherent in each elementary indicator while minimizing the loss of data. Furthermore, these indicators facilitate transparent ranking of areas (units) for which are calculated, enabling comparisons across different

spatial and temporal contexts. Thus, they offer an effective means of monitoring progress in intricate scenarios.

Effectively handling this wealth of information necessitates the implementation of feature extraction techniques that distill the most pertinent insights. Common methodologies include the arithmetic and the geometric means weighted or unweighted, which condense diverse data points into a singular score. These methodologies also include the Adjusted Mazziotta-Pareto Index (AMPI) Mazziotta and Pareto (2018) a sort of "reasoned" average of several elementary indicators, originally designed to measure well-being and the one used in this work to measure the socio-economic and demographic frailties within the suburban areas of Florence. Other examples of the use of AMPI or its variations can be found in Massoli et al. (2014) and Mazziotta and Pareto (2013). MPI and AMPI are still the golden standard for measuring sustainable and fair wellbeing (BES) in Italy. A fine-grain level of analysis, as the one performed in this work, could benefit surely both the researchers and policymakers interested in disentangling the drivers for fragility. Moreover, to the best of our knowledge, there were no previous published works on this topic, at this fine level of aggregation for the municipality of Florence.

Specifically, the construction of the index is in several steps. Let denote with $Y_{i,j}$ the socioeconomic or demographic outcome regarding the unit i and the indicator j. Then, the scaled matrix of indicators $R_{i,j}$ is defined as

$$R_{i,j} = \left[\frac{Y_{i,j} - min(Y_j)}{max(Y_j) - min(Y_j)}\right] 60 + 70$$

Subsequently, the AMPI index is obtained as

$$AMPI_i^{\pm} = M(R_i) \pm (S(R_i) \times cv(R_i))$$

where M, S, and cv are the mean, the standard deviation, and the coefficient of variation respectively, over the indicators for unit i. The sign of the elementary indicators depends on the nature of the phenomena we are willing to represent, for negative outcomes (such as fragility) we will add, while subtraction is used when a positive phenomena is evaluated, as in the case of Human development Index (HDI). See for further reference on the index construction Mazziotta and Pareto (2018).

In order to calculate the AMPI, first of all we have to identify the elementary index able to represent some main drivers for the identification of socio-economic and demographic fragility within the Florentine area. In particular, regarding the demographic aspect we consider the following elementary indicators: the share of the population aged 80 or more, the natural balance between births and deaths and the % population difference in the last 5 years. In this way, we should be able to catch up on some relevant demographic frailties: aging, low fertility and depopulation. Focusing on the economic aspects, we use as fragility indicators: the share of people under the poverty line (60% of the median income), the share of families under the poverty line, and the share of people paying rent, as a proxy of an insufficient capital accumulation. Lastly, we use several indexes for representing social fragility: the share of the 65+ population living alone, the share of minors in a single-parent family, the share of foreign-born minors over the minors, the share of unoccupied flats, and the share of the graduated population.

All the mentioned elementary indicators are based on data collected during 2021, with data sources shown in Table 1. Demographic and the social indexes are collected by the civil registry of Florence, while economic indexes are collected by the Italian Revenue Agency (Agenzia delle Entrate AdE) and further elaborated by the Municipality of Florence. Lastly, the % of graduates and the % of unused dwellings is derived from the 2011 census. Table 1 reports some relevant descriptive statistics for these elementary indexes.

As units of observation, we assume $N = 74$ suburban units in which the area of Florence is partitioned. These units represent a middle-level aggregation between the census areas and the administrative partitions of Florence, which could be too large for this study. Even if these units

stem from administrative sources, they represent homogeneous partitions of the city, particularly relevant for our purposes. Two of them were excluded from the analysis, as their population is too scarce to have reasonable estimates (under 100 inhabitants).

Table 1: Descriptive statistics of the elementary indexes - Mean, standard deviation, minimum, maximum median, first and third quantile.

Elementary Index	Mean	st.dev.	Min	25%	50%	75%	Max	Source
% Over 80	9.552	2.076	1.260	8.185	9.663	10.938	15.028	Fl. civil registry
Δ population	-2.826	3.584	-11.337	-4.512	-2.942	-1.554	16.098	Fl. civil registry
Natural Balance	-28.542	21.286	-94.200	-40.550	-25.700	-12.900	4.000	Fl. civil registry
% Over65 living alone	9.101	1.840	0.840	8.107	9.445	10.075	12.973	Fl. civil registry
% Under18 foreigners	15.948	8.407	2.308	10.322	14.375	19.197	39.159	Fl. civil registry
% Under 18 - Single parent	42.279	5.985	18.518	38.646	42.153	44.867	64.785	Fl. civil registry
% Unused dwellings	3.936	4.442	0.000	1.651	2.976	4.668	33.663	2011 Census
% Graduated	37.812	10.524	14.796	30.544	38.352	46.441	57.083	2011 Census
% New inhabitants	3.537	1.577	1.230	2.895	3.270	3.895	15.210	Fl. civil registry
% people under poverty line	33.110	3.925	21.171	30.780	32.696	34.801	44.231	AdE
% families under poverty line	20.401	5.037	7.353	17.696	19.343	21.381	34.499	AdE
% rents	20.366	6.823	8.092	15.506	19.109	25.119	37.841	2011 census

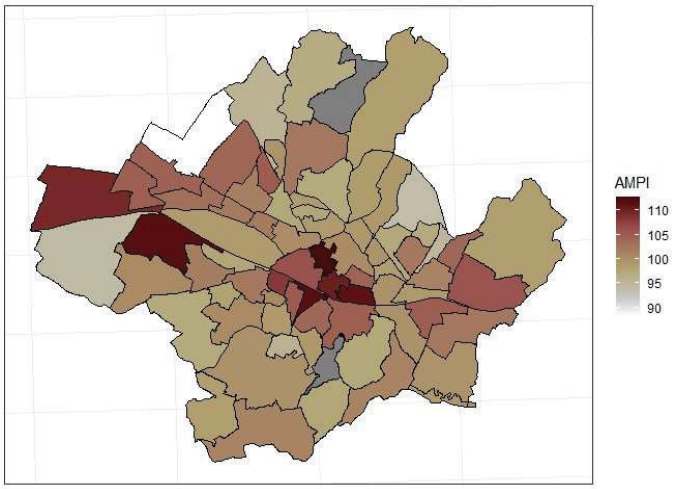

Figure 1: Map of Florentine socio-economic and demographic frailties, AMPI index

The comprehensive fragility map (Figure 1) highlights regions with sub-optimal performance, notably the city center and the northwestern quadrant, both displaying pronounced fragility. Interestingly, this finding might appear counterintuitive, considering the presence of esteemed artistic landmarks juxtaposed with challenging socio-economic conditions. Yet, a closer examination rationalizes this outcome: the historic city center features some of the oldest, relatively affordable residences, which could attract newcomers like migrants or students.

This conclusion gains further support when analyzing areas with significant mean-median income disparities. As shown in Figure 2, the urban core emerges as an income inequality hub, while the northwestern outskirts showcase near-parity between mean and median income.

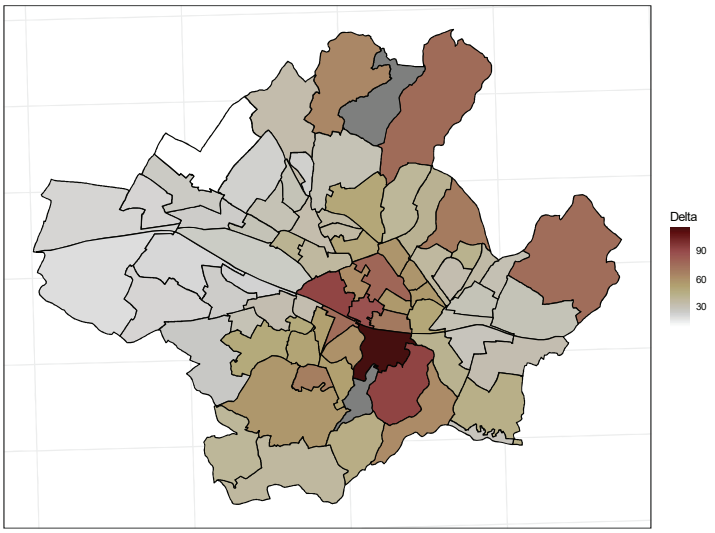

Figure 2: Income inequality measured as the difference between mean and median income, over the median income

3. Cluster analysis

Socio-economic fragility could be a phenomenon that could arise across different units, spatially contiguous or having similar characteristics. For this purpose, we perform a cluster analysis on our units, to investigate whether are present clusters of suburban areas with similar characteristics and enriching so the information set for policymakers. To classify units in the clusters, we adopt a clustering approach based on Gaussian mixture model, and implemented in R using the package mclust (Fraley and Raftery (2002), McLachlan et al. (2019)).

Cluster analysis points out the presence of five major clusters in Florence, as shown in Figure 3. The fifth cluster is composed only by one area, the airport, as it have completely different characteristics with respect the rest of the city. It is worth noting that the cluster analysis draws pretty well some homogenous areas, as follows:

The city center cluster: in pink, represent those areas within the old town of Florence

1. The hills cluster: in green, represents the bordering areas of Florence, encompassed into the hilly areas around the city. We can spot a higher mean age, with an associated higher demographic fragility.
2. The suburbs: in orange, represents the cluster of peripheral areas, located mainly in the northwestern part of the city, and the southeastern part. We notice these areas for a higher level of social fragility and economic fragility, but lower inequality.
3. The semicentral areas: in blue, represent the majority of Florence, with not many frailties to be spotted.

Figure 4 shows the weighted fragilities into the three domains of analysis and at the aggregate level for the aforementioned clusters. We can note that the city center is the most fragile and unequal area of Florence, with considerable issues both on the economic environment and on the social environment. In particular, we can see that the percentage of people and families living under the poverty line is abnormal with respect to the rest of the city. These results can be explained by the particular social composition of the city center, with many students and migrants that move inside the city because of more affordable rents. Similarly, we can notice social frailties in the city center and in the suburbs clusters, mainly due to the high percentage of foreigners and minors in single-parent families.

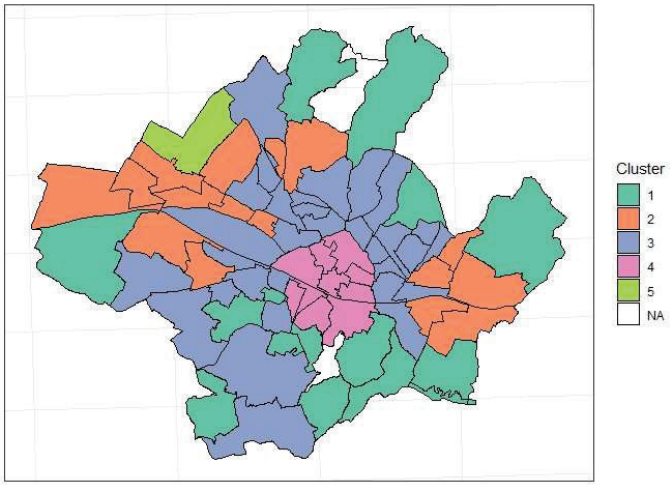

Figure 3: Cluster classification of suburban areas of Florence

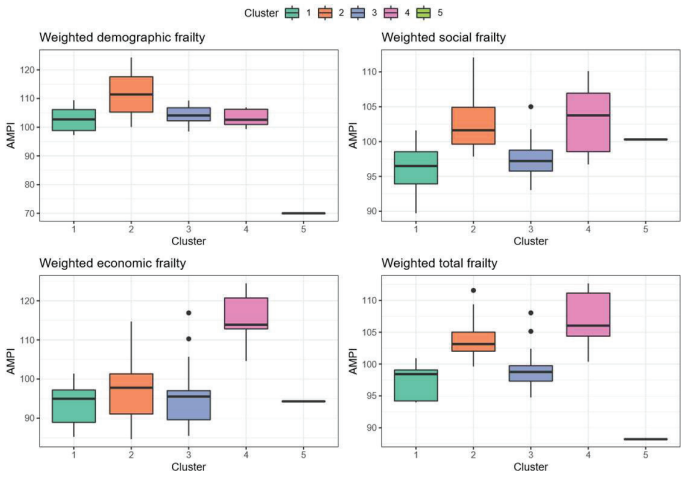

Figure 4: Boxplots of AMPI index for cluster frailties

4. Conclusion

In this work we aimed to assess suburban fralties of Florence, following three pillars: demographic, economic and social frailty. We showed that the use of synthetic indexes aggregated at suburban level could improve the local policymaker action, allowing for a detailed and focused action on the urban frailties. Our findings highlight substantial differences across suburban areas, thereby suggesting that fragility evaluations should be performed at the lowest possible level to capture potential heterogeneity, even at the municipal level. Intriguingly, areas with the highest fragility coincide with those exhibiting elevated economic inequality.

Cluster analysis has proven to be a valuable tool for validating, further explicating, and enhancing the interpretation of the succinct outcomes derived solely from the calculation of the synthetic index.

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