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Using urban environmental policy data to understand the domains of smartness: An analysis of spatial autocorrelation for all the Italian chief towns

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ABSTRACT

Despite the widespread implementation of policies tagged as 'smart', the concept of smart city itself still misses a solid and testable definition. Many scientific contributions used composite indicators to rank the cities according to their degree of smartness, often using un-robust methods and heterogeneous data. In this application we relied on statistical criteria to comprehend the principal components of smart policies. We used the environmental data coming from the Italian National Institute of Statistics (Istat), describing the adoption of smart policies in the urban environment (ICT use, smart mobility, green innovation, sustainable governance etc.). The indicators, covering all the Italian chief towns (116 cities), have been normalized and classified in order to derive a taxonomy for the smartness' domains. Rather than producing an overall ranking, the performances of cities have been analysed for each domain, with regards to the geographic location of cities. Northern cities show better performances overall. In order to investigate into the – Italian well-known – North-South polarization, we used spatial autocorrelations techniques to discover the localized clustering of cities with high or low scores. Belonging to the same administrative region and imitation effect are both possible explanations of the observed clustering.

1. Introduction

In recent years, many European cities have implemented a series of policies – tagged as "smart" – towards a innovative management of the urban environment and society. Those interventions were in part a response to the technological advances and to the continuing process of urbanization of the last decades. Those paths of innovation were associated to positive outcomes, such as the increase in productivity and the dissemination of knowledge, but also to problematic environmental conditions of cities getting bigger (congestion, waste disposal, emission of pollutant etc.). At the same time, the rising inequality in the distribution of wealth, marginalization and exclusion, and concerns over quality of life generated a feeling of uncertainty upon sustainability of the present situation. On the institutional side, the policies were guided by the recommendations of many international organizations. The strategy of the European Commission for the development of the Union (EU2020 strategy) gave a determinant input for smart policies to be designed, with the aim of guaranteeing sustainable economic development paying attention to the environment, societal welfare, and people's health. ICT and new technologies were intended as a tool to support people and to make those targets effective (European Commission, 2012).

However, there is little structured knowledge of the kind and extent of those policies, which are heterogeneous and fragmented. According to a recent report conducted in the UK, the impact of smart policies in improving the environmental condition of cities had proved to be small, mostly because of institutional barriers, intermittent funding and incentives, other areas of application of new technological devices.[1] Often, the smartness of cities was only related to the dissemination of mobile applications, completely forgetting the essence of a city's environment, with its related problems (Borruso and Murgante, 2015).

The concept of smart city itself, in spite of the growing number of scientific articles, still maintains a certain vacuity: a shared definition and a common taxonomy of its constituent items have yet to emerge in the literature (cf. paragraph 2.1). On the methodological side, many contributions rely on composite indicators to rank the cities according to their degree of smartness, using un-robust methods and heterogeneous data (see paragraph 2.2).

Also, although it has been argued that the spatial dimension impacts significantly on smart city policies, differentiating them one another

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[1] See *UK Environmental Industries Commision* (EIC, 2016), report available at: http://www.eic-uk.co.uk/report-will-smart-technology-clean-up-city-environments-/100/2/1/392.

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(Angelidou, 2014), there is no answer to the following question in the literature: is there an interaction among nearby cities which can impact on the smartness scores? In other terms, the strategic choices for a city to be smart have a spatial component that may play a fundamental role (see paragraph 5.2).

The considerations above motivate this study to pursue the following objectives:

a) to organize, structure and classify the information on the adoption of smart policies, referring to a unique and nationally representative source of data;
b) to identify the key components that synthesize the complexity of smart policy at urban level. These components, in turn, contribute to define the domains of smartness. The domains of smartness obtained from the data can be compared to those that have already been identified theoretically by other studies;
c) to evaluate the performances of cities in each smartness domain;
d) most importantly, to analyse those performances from a spatial perspective, investigating into the interactions among nearby cities.

To achieve the goals set, we used multivariate statistical techniques to synthesize the information coming from the data and to identify the components that had the most relevant impact among the smart policies. We derived a taxonomy which in turn contributes to ascertain and to define the domains of smartness. After that, we tested whether a spatial effect is significant in explaining the differences in performances. The spatial interaction in the various domains have been studied by means of a geographic-spatial analysis and localized autocorrelation techniques.

This contribution offers innovative achievements that differentiate it from other research both on the theoretical and methodological sides.

Firstly, the approach we adopted is distinctive. We decided not to impose a pre-determined classification of the smartness domains, in order to collect data and select indicators. Instead, in absence of a precise and testable definition of what smartness is, we let the data give an indication on what the domains of smartness could be. We moved *from* the data describing innovative environmental, eco-social and governmental urban policies, in order to understand which the main components are.

On the theoretical side, the underlying assumption is that the concept of smartness should not be super-imposed to a wider definition of well-being (treated elsewhere: e.g. see Stiglitz et al., 2009; Gigliarano et al., 2014; Istat, 2015). In our vision, smartness should have a *functional* role: technological advancement, environmental and societal innovation and intelligent governance should pursue the overall goal of promoting the well-being of the community who decides to adopt such tools. A smart management of the urban environment is the starting point for effectively enhancing people's well-being and quality of life.[2]

Also, this study improves on methodology, fixing some of the procedural shortcomings commonly found in the literature. Differently from many other contributions, we used a official, unique and comprehensive source of data, which is the most accurate for the adoption of smart policies in Italy (see par. 4). The full country coverage (all the chief towns) is also an improvement over others studies, which refer to heterogeneous mix of cities and sources of data. Instead, we deliberately avoided to associate cities located in un-comparable contexts.

We used consolidated and robust – yet easy-to-replicate – techniques. The reliability of our system of indicators is enhanced by procedures of normalization, checking of outliers and sensitivity analysis. For reporting, rather than producing an overall (and non-transparent) ranking, the performances had been analysed for each domain, in relation to the exact geographic location of the cities. The analysis of the spatial differences in the smartness domains is a novelty which can be useful for future research. One notable result is the interaction among group of nearby cities whose scores are influenced one another.

The rest of the article is organized as follows. The next paragraph is dedicated to a review of the literature on smart city, with a specific subsection about methodological issues involved in the measurements.

The methods are described in paragraph three, while the data and the basic indicators are described and analysed in paragraph four. Results are reported and discussed in paragraph five. It contains the results from components' extraction and a taxonomy for the smartness domains (5.1), the analysis of performances and clusters (5.2), a sensitivity analysis (5.3), a spatial analysis of interaction among nearby cities (5.4). Finally, chapter six concludes.

2. Background

2.1. The concept of smart city in the scientific debate

The notion of "smart city" emerged in the scientific literature in the late nineties (Van Bastelaer, 1998). Since then, the research interest in the area had increased: the number of studies on the topic boomed after 2010, reaching a number of nearly 200 articles published in 2012 (Cocchia, 2014). However, in spite of research efforts the concept of smart city still maintains a certain vacuity: a shared definition and a common taxonomy of its constituent items have yet to emerge. The following definitions, selected among the most cited in the literature, exemplify this diversity:

1. *"Smart city is defined as the use of information and communication technology to sense, analyze and integrate the key information of core systems in running cities" (Harrison et al., 2010).*
2. *"Smart City is where citizens, objects, utilities, etc., connect in a seamless manner using ubiquitous technologies, so as to significantly enhance the living experience in 21st century urban environments" (Northstream, 2010).*
3. *"A city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infra- structure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (Caragliu et al., 2011).*
4. *"A Smart City is a city well performing built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens" (Giffinger et al., 2007).*

The above definitions – as many others – ranged from a narrow view, typically related to ICT and technology (definitions 1 and 2; Harrison et al./IBM, 2010; Northstream; 2010), to broader ones encompassing quality of life and governance (3; Caragliu et al. 2011), well-being, social relations and awareness (4; Giffinger et al., 2007). The definitional problem also involves nomenclature, with a multiplicity of terminologies related to smartness, such as *Smart Energy City* (Mosannenzadeh et al., 2017), *digital city* (Couclelis, 2004) or, when the environment is concerned, *smart & sustainable city* (Ahvenniemi et al., 2017). Several systematic reviews tried to organize and rationalize the contributions (Kummitha & Crutzen, 2017; Anthopoulos, 2015, 2016; Albino et al., 2015).

Despite the non-consensus on how a smart city should be defined, a number of attempts to measure and rank the cities according to their degree of smartness have been proposed (see Ojo et al., 2016; Anthopoulos, 2016). According to a widely cited and re-proposed framework the domains of smartness could be classified into: *Governance*, *Economy*, *Mobility*, *Environment*, *People*, *Living* (Giffinger et al., 2007). Again, the classifications are sometimes wider (including health care, buildings and urban planning; Piro et al., 2014), or narrower (restricted

[2] This vision is in line with the definition of smartness adopted for policy purposes by the EU: '[a smart city is] *a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses'European Innovation Partnership on Smart Cities and Communities (EIP-SCC)*: http://ec.europa.eu/eip/smartcities/.