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Digital dimension of smart city: critical analysis

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Abstract

The analyses of publications show unclear differences between the definition of a digital city and a smart city. The critical analysis of references allows us to define the role of a digital dimension of a smart city. A deeper analysis of the concept of smart social systems shows that many social systems can be smart without necessarily basing their activities on Information and Communication Technologies (ICT). That is affirmed by the model of Jucevičius et al. (2013), where the social system is investigated taking into account its relationship with the environment. The paper considers the importance of a digital platform for the smart social systems of the city. Theoretical considerations have been used to develop a conceptual model for evaluation of the importance of a digital dimension for a smart city.

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1. Introduction

The topic of the presented abstract has two very important keywords: “digital” and “smart” city. The concept “a smart city” was first used in 1994 (Dameri, & Cocchia, 2013) and since the 2010 the number of publications regarding this topic has considerably increased. This is related to the appearance of smart city projects and support by the European Union (Dameri & Cocchia, 2013). According to the opinion of some authors, the city information systems influence the level of digitization of the city (Dirks & Keeling, 2009; Ergazakis et al., 2011). There are three main types of city systems: Operations Systems, City User Systems and City Infrastructure Systems. Digitization and interconnection of the city systems allow the citizens to be more informed, the level of knowledge can increase,

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positive conditions for becoming a learning city will appear. A powerful decision support system of the city allows the city government to make more realistic decisions.

The European Commission promotes development of digital cities. It is related to some priorities in The Digital Agenda for Europe (DAE). In most of the sources (Bakici et al., 2011; Micuraca et al., 2013) a smart system is associated with a digital platform. Bakici, Almirall, Wareham (2011) note the conditions that have to be achieved in order to get the system to function as a smart system. Thus the smart system must have suitable infrastructure, human capital and information. Consequently, in order to build smart economy one needs to have smart people, smart government, smart municipality, etc..

The digital dimension has a strong relationship with intelligence and innovativeness (Komninos, 2006, 2011). The same source asserts that ICT is the main platform of knowledge-creating organizations and intelligent cities.

As ICT is developing, the number of its users and uses increases. Presently there are about 50 such projects supported by the European Commission. Mandelson and Bradshaw (2009) identify ten main areas: health, effective use of resources, ICT literacy, public administration, education, regional economics, smart (green) transport, innovative services, culture and recreation, public safety. Each of those areas has many sub-areas and need separate analysis. All of them require suitable digital tools and ability to use them. Those tools create conditions for new workplaces - the rate of unemployment is also one of the indexes that represent (indirectly) the level of smartness of the city.

The problem of the research is to identify the factors most suitable for evaluation of "smartness" of the city and the relationship between "smartness" and digital dimension.

The aim of this research is to make analysis of literature and to design the model which will help us to evaluate the impact of digital indicators to a smart city rank.

2. Methods

In order to find the relation between a smart city and digital dimension it is necessary to find a set of indicators strongly related with digital dimension. The analysis of various studies shows many different indicators, but the motives of choice of the given indicators are less clear. It may seem that in many cases those indicators have been chosen intuitively. Some authors use as few as 28 indicators, some - up to 400. Also, the number of indicators concerned with the digital qualities is different in different studies. The universally accepted rules, that can give us the possibility to evaluate those indicators and their importance to digital qualities, do not exist. There are indicators that are clearly digital-related, for example, "Population qualified at levels 5-6 ISCED", "Computers in households", "smart phones holders". Other indicators, such as "Employment rate in the knowledge- intensive sector" or "Share of people working in creative industries" are less directly related to the digital dimension. Only some of the authors analyze the digital dimension separately. For example, the main characteristics of the model developed by Anthopoulos and Vakali (2012) are: e-democracy, e-business, e-health, tele-care services, e-learning, e-security services support, knowledge bases and infrastructure.

One of the most detailed studies is R. Giffinger's report. The components of R. Giffinger's model (Giffinger et al., 2007) include: Smart Economy, Smart Environment, Smart Governance, Smart Living, Smart Mobility, and Smart People. Each characteristic is described by the set of factors used by Giffinger (2007) and Cohehen (2013). In total, 74 indicators were selected: 48 (65 %) are based on the local or regional data and 26 (35 %) are based on the national data. The factors used by R. Giffinger are marked by G, and the factors used by B. Cohehen are marked by C (Table 1). The table also shows the number of digital indicators (for Giffinger) and the factors (for Cohenen) and the total number of indicators and factors.

Table 1. Smart city factors used by Giffinger's (2007) and Cohehen (2013) together with the number of digital indicators (for Giffinger) and the factors (for Cohenen) and the total number of indicators and factors

Smart economy	**Used**	**Smart people**	**Used**	**Smart governance**	**Used**
Innovative spirit	**G, C**	Level of qualification	**G**	Participation in decision-making;	**G**
Entrepreneurship	**G,C**	Affinity to lifelong learning	**G**	Public and social services	**G**
Economic image & trademarks	**G**	Social and ethnic plurality	**G**	Transparent governance	**G**
Productivity	**G, C**	Flexibility	**G**	Political strategies & Perspectives	**G**
Flexibility of labour market	**G**	Creativity	**G, C**	Demand policy	**C**
International embeddedness	**G**	Cosmopolitanism/Open-mindedness	**G**	Transparency & open data	**C**
Local and global interconnectedness	**C**	Participation in public life	**G, C**	ICT & government	**C**
		Education	**C**		
Digital/Total	**G(2/12), C(2/3)**	Digital/Total	**G(1/15), C(3/3)**	Digital/Total	**G(2/9), C(2/3)**
Smart mobility	**Used**	**Smart environment**	**Used**	**Smart living**	**Used**
Local accessibility	**G**	Natural conditions	**G**	Cultural facilities	**G, C**
(Inter) national accessibility	**G**	Pollution	**G**	Health conditions	**G, C**
Availability of ICT-infrastructure	**G, C**	Environmental protection	**G**	Individual safety	**G, C**
Sustainable innovative and transport systems	**G, C**	Sustainable resource management	**G**	Housing quality	**G**
Mixed modal access	**C**	Green buildings	**C**	Education facilities	**G**
		Green energy	**C**	Touristic attractiveness	**G**
		Green urban planning	**C**	Social cohesion	**G**
Digital/Total	**G(2/9), C(3/3)**	Digital/Total	**G(1/9), C(3/3)**	Digital/Total	**G(0/20), C(1/3)**

The list of indicators used by other researchers was different (28-400). B. Cohen's smart city model gives characteristics similar to R. Giffinger's, but the factors are different, with more strongly expressed digital dimension. This model has separate factors, such as Open data, ICT & e-government, Integrated ICT. B. Cohen uses far fewer indicators to find the smart rank. Other authors (Dirks & Keeling, 2009) have prepared models that make it harder to notice the digital dimension, since they include only very general factors, such as city services, water, communications, transport, business.

As it can be seen, the digital dimension is distributed among the characteristics of smart cities. Thus it is possible to use the model of smartness that emphasizes this fact (Fig. 1).

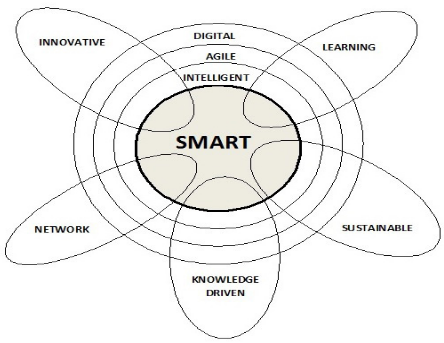

Figure 1. Modification of the smartness model by Jucevicius et al (2013)

However, a more comprehensive analysis of the concept of smart social systems shows that many social systems can be smart without necessarily basing their activities on ICT. That is affirmed by the model of Jucevičius et al (2013), where the social system is investigated taking into account its relationship with the environment. This model highlights such qualities as being intelligent, knowledge-based, informational, learning, networked, innovative, mobile, and sustainable. All that can be achieved by adjusting to the system's environment. As it can be seen, the features of this model are similar to the characteristics described in the literature. The model in Fig.1 differs from other models by clearly showing how the digital dimension underlies all characteristics. Thus, in analyzing "smartness" it makes it easier to evaluate digital dimension specifically.

The biggest part of researches for determination the smartest city usually uses a ranking method (Cohehen, 2013, Giffinger, et al., 2007, 2010). Some authors use a fuzzy method (Anthopoulos et al., 2011), some authors use simulation (Patasius et al., 2013). Each method requires definition of the characteristic that influences the level of "smartness". Each characteristic can be described by specific factors and each factor can be assigned to the indicators the values of which can be found in the databases, during the analysis of the secondary data. When that cannot be done, it is possible to perform special surveys or to collect additional data in some other way.

3. Results

Smart social structures tend to be highly dynamic. Thus it seems more suitable to perform the analysis by evaluating "smartness" dynamically as well. Since many of the characteristics commonly used for evaluation are somewhat subjective, it is reasonable to use fuzzy logic – specifically, fuzzy cognitive maps (FCM) (Fig. 2), since they are often used for predictive mathematical analysis of the social data.

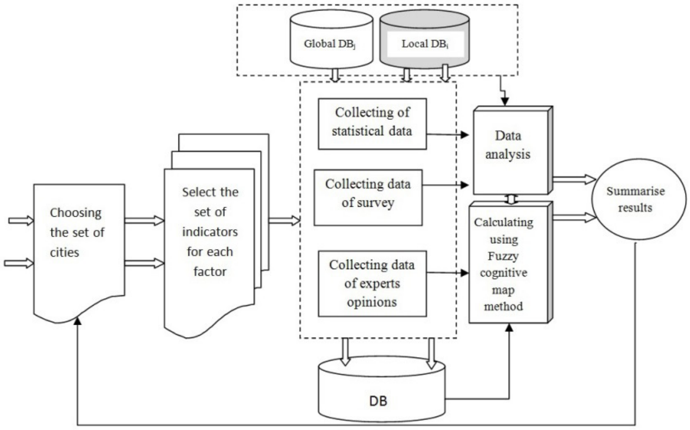

Figure 2. Model of evaluation digital dimension in smart city ranking

At the beginning of this evaluation process both cities to be ranked and the indicators to be used for evaluation have to be chosen. Next, the necessary data has to be collected for storage in the database. Then the analysis of the data prepares the coefficients and starting conditions for FCM modeling. It is especially useful to adapt SWOT analysis of the cities for such use, as SWOT analysis has already been found useful for the preparation of FCM models of social systems.

The FCM model returns predicted trends of changes of separate indicators (steady or chaotic). From them, indices that can be used for ranking of the chosen cities can be calculated. That would make it easier to choose the set of the cities in a more useful way.

4. Discussion

This study emphasizes that, while digital dimension does not dominate in any of the main categories of features of smart cities, it is important to all of them. The model that can be used for a dynamic analysis of smart city policies and results has been proposed. In the future its specific features will have to be fully investigated.

In order to perform the research according to the proposed model, a lot of data is required, which means that in this case the time and effort needed for investigation will also depend on the digital dimension of smart social structures.

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