REFLECTIONS ON EVOLVING URBAN CORRELATIONS FOR CONNECTED SMART CITIES

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ABSTRACT

The purpose of this reflection paper is to explore emerging potentials for the use of correlation, in combination with a case study design, as a hybrid approach to identifying and understanding patterns and relationships in smart cities. A review of the research literature is provided for perspectives on correlation, the application of correlation in urban environments, and emerging approaches to the use of correlation in relation to smart cities. Focusing on people and their experience of urban spaces, elements, and digital interactions, the relationship of openness and connectedness is explored. Using multiple methods of data collection including survey and in-depth interviews, a combination of content analysis and explanatory correlational design is used in the analysis of data. Findings shed light on the relationship between openness and connectedness in smart cities. This paper is significant in that it contributes to the research literature on smart cities; advances the innovating of methodologies for the study of smart cities by combining case study and correlational design; sheds additional light on the connected dimension of smart cities; and highlights the importance of why correlation matters in smart cities.

KEYWORDS

Connectedness, Correlation, Mutual Information, Openness, Pearson Correlation, Relationships, Smart Cities, Urban Correlations

1. INTRODUCTION AND BACKGROUND

The purpose of this reflection paper is to explore emerging potentials for the use of correlation, in combination with a case study design, as a hybrid approach to identifying and understanding patterns and relationships, in smart cities. To this end, the research literature is reviewed for perspectives on correlation; the application of correlation in urban environments; and emerging approaches to the use of correlation in the context of smart cities. Focusing on people and their experience of urban spaces, elements, and digital interactions, the relationship of openness and connectedness is explored. Using multiple methods of data collection including survey and in-depth interviews, a combination of content analysis and explanatory correlational design is used in the analysis of data. This work is motivated by the need for approaches to “make visible what is normally not” (Quercia, Séaghdha, and Crowcroft, 2017) in smart cities while moving beyond the static to the dynamic in accommodating the “connected” and continuous nature of activities and interactions in technology-pervasive urban environments (Bermudez-Edo, Barnaghi, and Moessner, 2018). As such, this paper uses a combination of case study and correlational statistical research to explore patterns and relationships in smart cities. This paper is significant for at least four key reasons in that – it contributes to the research literature on smart cities; advances the innovating of methodologies for the study of smart cities by combining a case study design with an explanatory correlational design; sheds light on the connected dimension of smart cities; and highlights the importance of why correlation matters in smart cities.

2. CORRELATION: A REVIEW OF THE LITERATURE

Through a review of the research literature, perspectives are provided in this section on the use of correlation generally and on urban correlation in relation to smart cities.

2.1 Perspectives on Correlation

In the context of social research methods, Trochim (2006) describes correlation as “a single number that describes the degree of relationship between two variables” while from an information science perspective, Oakleaf (2014) highlights the need to “recognize the utility of correlational connections.” Creswell (2018) describes correlational research in the context of education research as “designs to describe and measure the degree of association (or relationship) between two or more variables or sets of scores.” Creswell (2018) indicates that correlation is also used to “predict an outcome” noting that types of correlational designs include explanatory design and prediction designs (2018). Correlation coefficients are described by Bermudez-Edo et al. (2018) as “tools to measure the dependency of two or more variables” such as the Pearson correlation coefficient and that of mutual information. Kaethler (Kaethler and Golchehr, 2017) problematizes “the correlation-based approach” to urban areas in the form of a lament, arguing that, “data mining will disorient the emergence and retention of urban narratives.” For Kaethler (Kaethler and Golchehr, 2017), “the story telling that occurs, internally and externally” in urban spaces “is threatened by a data-centered approach.” In response, in the form of a postscript in the same paper, Golchehr (Kaethler and Golchehr, 2017) articulates, “a defence of data mining as a new means through which socially innovative narratives can evolve.” In the form of a “rebuttal”, Golchehr (Kaethler and Golchehr, 2017) advances the importance of “an open mind” in support of the “use of correlation as the starting point for the narratives we create.” Yin (2018) points to the “complementarity of case study and statistical research” where “case studies have been needed to examine the underlying processes that might explain a correlation.”

2.2 Urban Correlation in Smart Cities

Lathia, Quercia, and Crowcroft (2012) use correlation to explore community well-being in urban areas in relation to mobility. Through leveraging the potentials of pervasive technology, Lathia et al., (2012) “test whether urban mobility – as measured by public transport fare collection sensors – is a viable proxy for the visibility of a city’s communities.” Quercia et al. (2012) “extract the subject matter of tweets using ‘topic models’” from London census communities and use correlation to “study the relationship between topics and community socio-economic well-being.” Hernando, Hernando, and Plastino (2013) demonstrate the use of space-time correlations in relation to urban sprawl. Dattakumar and Sharma (2016) explore the development of smart cities and knowledge societies in relation to correlation and causation or something altogether distinct from the two, advancing a “maturity model for smart cities and knowledge societies” while making a “conjecture that there may be a synergistic, rather than symbiotic, link” between the two. And it is worth noting that Gil-Garcia, Zhang, and Puron-Cid (2016) identify openness as one of several dimensions of smartness in government. Quercia et al. (2017) leverage the smartness of pervasive technologies to learn about people and well-being in making cities more livable based on the “creative use of network-generated data” in “capturing sensory and psychological perceptions at scale.” Focusing on the human senses (e.g., sight, smell, hearing, and emotion), according to Quercia et al. (2017), it is “reasonable to assume that, from digital footprints” in social media and other spaces “one could derive good proxies for the different ways people perceive streets.” Zhuhadar et al. (2017) describe systems capable of correlating events in smart cities and in the context of e-Government research, Joshi and When (2017) identified the variable of “citizen discussion via social media” highlighting people as “social sensors.” Redi et al. (2018) “explored the possibility of using social media data to reliably map the ambiance of neighborhoods” throughout London while using correlation in “explaining neighborhood ambiance.” Covatta (2018) highlights the importance of “play as an urban tool to reuse the infrastructure” using examples from the city of Copenhagen. Drawing on the research work of Gehl (1987) and his partner, Ingrid Mundt, Covatta (2018) notes that “data collection regarding citizens’ movement and behavior become precious information for governments and municipalities” in support of “participatory design proposals” that are “based on the small scale intervention of people’s behavior.” Bermudez-Edo et al. (2018) provide an analysis of “real world data streams” using “spatio-temporal correlations” in smart cities as a “proposed method” to “analyze relations in IoT.” Bermudez-Edo et al. (2018) argue that, “one of the main starting points to analyse these big amounts of data is correlation detection” claiming that their “analysis contributes to optimize the use of the available infrastructure” in order “to better plan the future urban deployments.” Focusing on “road infrastructure” and traffic flow, the work of Bermudez-Edo et al. (2018) “demonstrated that for both, synthetic and real data,

mutual information can discover dependencies in more general cases of distribution of data” while “Pearson correlation can discover linear distribution of data” concluding that “sample size is important” in that “it influences the correlation methods.”

3. EXPLORING RELATIONSHIPS IN SMART CITIES

Using an exploratory case study approach in combination with an explanatory correlational design, this work seeks to provide insight into connectedness and openness in the context of smart cities. Data collection involved the use of survey and in-depth interviews focusing on the experience of smart cities. The study attracted a wide range of individuals from small to medium to large-sized cities, mostly in Canada and extending also to Europe, and Israel.

3.1 Connectedness and Openness in Smart Cities

Respondents were asked to assess the extent to which they associate smart cities with *openness* on a 7-point scale, with 1=Not at all, to 7=Absolutely. Responses were spread across the upper points on the scale with 25% at the neutral position of 4, 25% at 5, 25% at 6, and 25% at 7. When asked to assess connecting in smart cities on a 7-point scale, responses were slightly higher with 25% at position 5 on the scale, 25% at 6, and 50% at 7. Using the Real Statistics data analysis tool in Microsoft Excel, the correlation is calculated for openness and connecting in smart cities. A scatter plot diagram of the data shows the direction of the correlation to be positive, taking a linear form, with the strength of the relationship considered to be very good, falling as it does in the .66 to .85 range (Creswell, 2018), based on a Pearson Correlation coefficient of .67.

Through open-ended survey questions and in-depth interviews, people contributed additional insights with their comments about connecting and openness, where a city councilor observed that, “vibrancy is created by people and connections between people” describing technology “as a tool that will allow people to connect to each other and to their surroundings” as in, “creating activity.” A technology consultant described “smart city thought processes” as “wonderful things that connects all the pieces.” Referring to public data, city information technology (IT) staff indicated that, “fundamentally there is a desire to be very, very open with the available data.” City IT added that “we are interested in putting physical infrastructure in place” and “how we interpret using it is still open.” An educator identified the need for schools to open their “walls”, when asked how “to get people more involved in the city and the community.” Cities were described as affording “a sense of freedom and openness” when asked, “what do you like about being in the city?”

3.2 Limitations and Future Directions

Going forward, the use of correlation in smart environments provides an opportunity or, in the words of researchers such as Bermudez-Edo et al. (2018), a “starting point” for the analysis of relationships and for “the narratives we create” (Kaethler and Golchehr, 2017) in urban spaces. Indeed, considering the work of Quercia et al. (2017) where correlation is used to “make visible” what is not visible, this would seem to support the relevance of correlation for smart city-related research where the characteristic of invisibility is said to be a particular challenge (McKenna, 2019), offering possibly novel analytic methodologies and approaches with implications for urban theory. While this paper is limited by a small sample size and a focus on only two variables (e.g., openness and connectedness), opportunities exist to enlarge the exploration to include more participants and variables going forward and it is worth noting that Dattakumar and Sharma (2016) articulate a range of questions for future research such as, “can smart cities enhance creativity?”

4. CONCLUSION

This work probes the relationship of openness and connectedness in contemporary urban environments as a starting point for learning more about what contributes to the making of smart cities. A combined case study

and correlational research design was used, informed by a review of the research literature for smart cities and correlation, as an approach to the exploration of connected smart cities that are characterized by more aware people interacting with increasingly aware and pervasive technologies. Findings show a positive and reasonably good relationship between openness and connectedness. Going forward, this work sets the stage for further work focusing on variables surfaced by researchers (Dattakumar and Sharma, 2016; Joshi and When, 2017; McKenna, 2019) in urban spaces. Enabled by more aware people interacting with aware technologies, this type of exploration provides novel opportunities for continuing to push at the edges of the use of correlation in smart cities, communities, and regions, in figuring out what contributes to the success of smart city projects and of smart cities more broadly. This paper is also significant in that it contributes to the research literature by highlighting the importance of correlation in the context of smart cities; demonstrates the use of correlation as an approach to exploring what is it that makes smart cities connected and why this matters; and extends urban theory and methodological approaches to include correlation.

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