

UNDERSTANDING THE RELATIONSHIP BETWEEN FIRMS' LEVEL OF KNOWLEDGE ON THE SMART CITY CONCEPT AND THE SIZE OF THE FIRM – AN EMPIRICAL STUDY

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Purpose: On the one hand, companies become consumers of a smart city, but on the other, they are also co-creators and/or initiators of new goals. The implementation of the smart city concept requires specific knowledge, especially from businesses, who are active participants in the process. The aim of the paper is to gain new knowledge about the relationship between firms' level of knowledge on the smart city concept and the size of the company.

Design/methodology/approach: The survey was carried out in 2021 using the CATI, CAWI interview method on a random sample of 217 companies in the West Pomeranian region in the Republic of Poland. The Chi-square test for independence and the Kruskal-Wallis test were conducted.

Findings: A Kruskal-Wallis H test revealed no statistically significant difference in the level of smart city knowledge across the five analyzed groups based on company size. The study results indicate no significant association between company size and the four selected statements regarding smart city concept. The presented data could be the basis for the preparation of an appropriate strategy for sustainable operation, taking into account the important factor, which is people, including entrepreneurs.

Research limitations/implications: The authors suggest conducting the same analysis with a larger sample size to generalize the phenomena. The authors believe that it is worth examining the level of knowledge not only of companies from the West Pomeranian voivodeship, but also from all over Poland, which may precisely illustrate the level of understanding of the smart city concept.

Practical implications: Research results are important not only for regional policymakers but also for researchers interested in the field of strategic smart city development. Due to changes taking place in the perception of the city's role, the concept of a smart and sustainable city is becoming increasingly important not only for city authorities but also for businesses.

Social implications: The implementation of the smart city concept requires conscious and thoughtful steps, but also created in cooperation with all participants, especially residents and businesses, who are active participants in the process.

Originality/value: Addressing a research gap in association between company size and the knowledge about the smart city concept, this study sought to provide valuable insights.

Keywords: smart city, sustainable development, companies, sustainability.

Category of the paper: Research paper.

1. Introduction

A smart city is a concept that, at its core, is understood as the implementation of modern technologies related to both IT and the construction of networks or databases, as well as platforms for communication (Sugandha et al., 2022; Townsend, 2013). The development has led the concept of a smart city to a point where, alongside modern solutions and technology implementation, there is a focus on sustainable development and the realization of social goals (Mappiasse, 2015; Aurigi, Odendaal, 2021). In the contemporary concept of a smart city, various ideas are present, such as smart city development, including service innovation, urban intelligence, urban sustainability, urban openness, infrastructure integration, urban innovation, collaborative partnership, and smart city governance (Gil-Garcia, Pardo, Nam, 2015; Lai, Cole, 2022).

In the literature, the prevailing belief is that the quadruple helix model is the best to activate all stakeholders. This model brings together four key players: government, citizens, solution-providing corporations, and SMEs for local solution implementation (Kummitha, Crutzen, 2019).

It is also important to emphasize that the process of urban development is necessary to improve life quality in the city of the growing urban population (56% of the world's population lives in cities) (World bank, 2023). Therefore, modernizing the city's operations becomes essential to meet the needs of residents and address the challenges of large metropolitan areas (Homer, 2023).

Implementing modern solutions in cities allows for addressing complex social and environmental issues. However, modern technologies are not capable of solving all urban problems and can simultaneously create issues related to human factors and constraints in implementing a human-centered city concept. (Aina et al., 2019). Especially, if we take into consideration that there is no equal access for each human to high-tech.

The concept of a smart city is a relatively new idea and encompasses various scientific disciplines, often being associated with the concept of a sustainable city. This is because modern technologies are intended to support a city in providing a better life for its citizens and preventing issues related to the unsustainable development of urban agglomerations (Schiavo, Magalhães, 2022).

Therefore, the main research trends in the field of smart cities focus on technological development, urban development, and awareness of sustainable development. This combined concept is referred to as the hybridization of a smart sustainable city (Höjer, Wangel, 2015).

In addition, efforts are being made to conceptualize the smart city, but empirical research is still lacking (Ahvenniemi et al., 2017). This paper tries to fill in that research gap and provide knowledge related to the understanding of the smart city concept among companies.

The current concept of smart city has advanced to the third level - Smart City 3.0, which focuses on co-creating smart cities with residents and gaining their acceptance. The earlier Smart City 2.0 concept referred to activities that combined smart cities with sustainable urban development, while the original Smart City 1.0 concept was about implementing modern technologies to create an intelligent city (Giela, 2023).

Unfortunately, there is no single blueprint to follow that can be adopted to create successive smart cities, even as the availability of various technologies increases (Kummitha, 2019).

The increasing involvement of citizens in the smart city concept suggests that businesses operating within a city can also play a significant role in this concept. On one side, they are market entities, but on the other hand, they are entrepreneurs, and often residents of the city as well. This dual role of local entrepreneurs is seen as both implementers of modern technologies in their companies, contributing to the city's development, and as recipients of services offered by the smart city.

At this point, it should be emphasized that the development of a smart city depends on business growth. The size and quantity of corporations also have a significant impact on the implementation of the smart city concept. Without the development of entrepreneurship, the progress of a smart city cannot take place, as the inflow of private capital will condition both the city's revenues and its development. Entrepreneurship development is closely related to the smart city concept as well (Yigitcanlar, Velibeyoglu, Martinez-Fernandez, 2008; Richter, Kraus, Syrjä, 2015).

The relationship between smart cities and entrepreneurial activities is synergistic. This means that a smart city cannot function without innovative, forward-thinking businesses. Companies focused on growth and new technologies seek opportunities and a business-friendly environment provided by smart cities. Companies with similar structures also gravitate toward each other, and industries unite around common visions. It is also important to highlight that cities that tailor their environment to current needs and provide access to creative, talented individuals become attractive to innovative businesses (Marchesani, Masciarelli, Bikfalvi, 2023).

Examples of such initiatives include industry clusters, networks, start-ups, or collaborative development of local applications. To stimulate innovation among small and young businesses, hackathons are organized by city authorities.

Addressing a research gap in association between company size and the knowledge about the smart city concept, this study sought to provide valuable insights. Therefore, the aim of the paper is to gain new knowledge about the relationship between firms' level of knowledge on the smart city concept and the size of the company. This paper consists of five sections. In the second section 'Methods' two conceptual frameworks and five hypotheses were described. The third section focuses on presenting research results regarding self-evaluation of understanding the smart city concept, perceived characteristics of a smart city, association between company size and the chosen characteristics of a smart city and the difference between the level of knowledge across five group of companies based on the company size. The next section, 'Discussion', provides primary conclusion with the reference to other studies. The paper finished with the summary.

2. Methods

To guide the study, two conceptual frameworks were devised. First, the authors explored companies' perspectives on four distinct aspects of a smart city, considering variations based on company size (Figure 1). The chosen dimensions encompass 'modern technologies used in the city', 'the city's impact on improving the quality of life for its residents', 'the city's capacity for analyzing, monitoring, and utilizing data', 'the city's commitment to working for the benefit of future generations'.

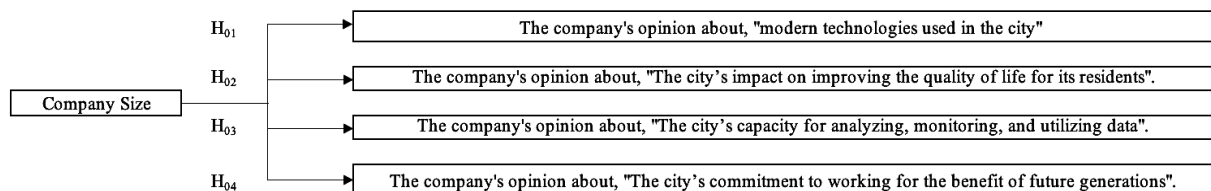


Figure 1. Conceptual framework of study I.

Source: own elaboration.

Accordingly, formulated hypotheses are:

H01: The company size and the company's opinion about modern technology used in the city are independent.

Ha1: The company size and the company's opinion about modern technology used in the city are not independent.

H02: The company size and the company's opinion about the city improving the quality of life of its residents are independent.

Ha2: The company size and the company's opinion about the city improving the quality of life of its residents are not independent.

H03: The company size and the company's opinion about the city analyzing, monitoring, and using data are independent.

Ha3: The company size and the company's opinion about the city analyzing, monitoring, and using data are not independent.

H04: The company size and the company's opinion about the city working for future generations are independent.

Ha4: The company size and the company's opinion about the city working for future generations are not independent.

Further, the authors examined whether the median knowledge levels differed among various groups. Guided by conceptual framework of study II, the authors ran a Kruskal-Wallis H test (Figure 2).

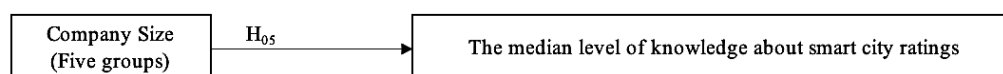


Figure 2. Conceptual framework of study II.

Source: own elaboration.

Companies were categorized into five size groups: one-person company, micro company (1-9 employees), small company (10-49 employees), medium company (50-249 employees) and large company (250 employees and above). Formulated hypotheses are:

H05: The median knowledge about smart city ratings across the five groups is equal.

Ha5: At least one of the median knowledge about smart city ratings is different from the others.

The survey was conducted in 2021 using Computer-Assisted Telephone Interviewing and Computer-Assisted Web Interviewing methods on a random sample of 217 companies in the West Pomeranian region in the Republic of Poland. The sampling frame was a database of companies from the Flow Research Centre. The research was anonymous. In this paper 3 out of 21 questions from the questionnaire were utilized. The analyzed questions pertain to the self-evaluation of understanding the smart city concept, the perceived characteristics of a smart city and the size of the company. This regional research was carried out in two largest cities in the region – Szczecin and Koszalin which are the only cities in the region with population exceeding 100 thousand. According to the research methodology of the regional study, this sample can be considered as representative (Bazarnik, Grabinski, Kaćiak, 1992). The data represented ordinal and ratio scale. The authors used nonparametric tests (Stevens, 1946). The Chi-square test for independence ($\alpha = 0.01$) and the Kruskal-Wallis test were both conducted.

3. Results

The total number of respondents was 217 companies. Out of the total 271 respondents, 128 were one-person companies, 60 were micro companies, 19 were small companies, 5 were medium companies and 5 were large companies (Table 1). In the initial phase, entrepreneurs were queried about their self-assessment of knowledge regarding smart city concept.

Table 1.
Self-evaluation of understanding the smart city concept

Size of the company	Count	Sum	Average	Variance
One-person company	128	8405	65.66	692.68
Micro company	60	3944	65.73	538.94
Small company	19	1205	63.42	566.7
Medium company	5	339	67.8	565.2
Large company	5	299	59.8	99.7

Count – number of respondents (sample size).

Sum – the summation of the scores given by the respondents based on the scale from 0 to 100.

Source: own study based on the survey.

The respondents were instructed to provide answers on a scale from 0 to 100, where 0 indicated a lack of knowledge and 100 represented a comprehensive understanding of the smart city concept. The average self-assessment of knowledge ranged from 59.8 for large companies to 67.8 for medium companies.

Further, respondents were given the opportunity to express their opinion on whether four selected statements accurately characterize the broadly understood concept of a smart city (Table 2). The authors employed a Likert scale for this question.

Table 2.
The perceived characteristics of a smart city by the respondents

Statement		Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree	Sum
Modern technologies are used in the city	f	18	32	19	64	84	217
	%	8%	15%	9%	29%	39%	100%
The city improves the quality of life of its residents, responds to the needs of its residents	f	25	27	20	62	83	217
	%	12%	12%	9%	29%	38%	100%
The city analyzes, monitors and utilize data	f	24	29	26	54	84	217
	%	11%	13%	12%	25%	39%	100%
The city works for the benefit of future generations	f	26	30	21	54	86	217
	%	12%	14%	10%	25%	40%	100%

f – frequency,

% – percentage.

Source: own study based on the survey.

Upon analyzing the data presented in Table 2, it is evident that respondents predominantly agreed or strongly agreed with the selected statements characterizing a smart city. The respondents most frequently associated a smart city with the use of modern technologies and least frequently with a city's capacity for analyzing, monitoring, and utilizing data. However, the variations in responses are subtle.

Furthermore, the authors sought to investigate the association between company size and the four selected statements (Table 3).

Table 3.
Summary of the chi-square test of independence

Hypotheses	Chi-Sq test Statistic	df	α	p-value	Observation	Decision
H01	11.65	16	0.01	0.767	p-value > α	Fail to reject the null hypothesis
H02	10.72	16	0.01	0.826	p-value > α	Fail to reject the null hypothesis
H03	17.13	16	0.01	0.377	p-value > α	Fail to reject the null hypothesis
H04	9.21	16	0.01	0.904	p-value > α	Fail to reject the null hypothesis

df – degree of freedom,
 α – type I error.

Source: own study based on the survey.

A chi-square test of independence showed that there was no significant association between company size and the company's opinion about modern technology used in the city, $\chi^2(16, N = 217) = 0.767$, $p > .01$ (see Table 3). Thus, the researchers failed to reject the null hypothesis.

A chi-square test of independence showed that there was no significant association between company size and the company's opinion about the city's impact on improving the quality of life for its residents, $\chi^2(16, N = 217) = 0.826$, $p > .01$. Thus, the researchers failed to reject the null hypothesis.

A chi-square test of independence showed that there was no significant association between company size and the company's opinion about the city's capacity for analyzing, monitoring, and utilizing data, $\chi^2(16, N = 217) = 0.377$, $p > .01$. Thus, the researchers failed to reject the null hypothesis.

A chi-square test of independence showed that there was no significant association between company size and the company's opinion about the city commitment to working for the benefit of future generations, $\chi^2(16, N = 217) = 0.904$, $p > .01$. Thus, the researchers failed to reject the null hypothesis.

Lastly, the authors endeavored to explore whether the median knowledge about the smart city concept varies based on the company size.

Table 4.
Summary of the Kruskal-Wallis H test

Company Size	n	Mean rank	χ^2	df	Sig.	α
One-person company	128	111.50	1.28	4	0.865	.01
Micro company	60	108.10				
Small company	19	101.21				
Medium company	5	110.00				
Large company	5	84.40				

n – sample size,

χ^2 – Chi-square test Statistic,

df – degree of freedom,

Sig. – p-value,

α – type I error.

Source: own study based on the survey.

A Kruskal-Wallis H test showed that there was no statistically significant difference between the level of smart city knowledge across these five groups of companies based on the company size, $\chi^2(4) = 1.28$, $p = 0.865$, with a mean rank of knowledge about the smart city of the group one (one-person companies) was 111.50, group two (micro companies) was 108.10, group three (small companies) was 101.21, group four (medium companies) was 110.00 and group five (large companies) was 84.40.

4. Discussion

A primary conclusion drawn from the study is that a chi-square test of independence revealed no significant association between company size and the company's opinion on the various aspects of a smart city, including 'modern technology used in the city', 'the city's impact on improving the quality of life for its residents', the city's capacity for analyzing, monitoring, and utilizing data' and 'the city's commitment to work for the benefit of a future generation'. In the authors' opinion, the obtained results challenge the common belief that larger companies, equipped with greater resources (knowledge/specialization), possess a more profound understanding of the smart city concept. This raises a research question regarding the cause of the lack of a significant association between company size and the company's opinion on various aspects of a smart city. Could the absence of a correlation be attributed to the fact that small companies, such as start-ups, may have innovative solutions, while large specialized firms may possess knowledge in areas such as urban infrastructure planning? In both cases, companies are acquainted with and have knowledge about different aspects of the smart city.

It could be argued that the multifaceted nature of the smart city concept, as indicated in the literature (Lai, Cole, 2022; Homer, 2023; Szczepańska et al., 2023), may influence the state of knowledge, i.e., 'everyone knows something/some.' It is also noteworthy that the entrepreneurial ecosystem of the smart city (Mitra et al., 2023) has not been fully explored,

and there is a lack of comprehensive studies on this topic. Consequently, the obtained results are challenging to compare with other researchers' works, and this observation is associated with the need to identify underlying causes.

The research aimed to bridge a gap in understanding the relationship between company size and knowledge about the smart city concept. This emphasizes the importance of educating and raising awareness about the smart city concept. Relating to the literature review, it is highlighted that corporate solutions may not always be universally suitable for addressing specific urban challenges (Kummitha, 2019).

The authors aspire that the knowledge about the smart city concept among the identified group of entrepreneurs will serve as a source of inspiration for other researchers. The authors emphasize the difficulty of implementing the smart city concept if stakeholders lack a comprehensive understanding of it. In general, knowledge management is crucial for multinational companies, influencing global competitiveness and, in turn, the quality of life for people (Vetrakova, Smerek, 2019). To improve quality of life, all components involved in the city must be optimally managed (Ruiz-Vanoye et al., 2023). The importance of such activities is highlighted in the literature review, as the improvement of the overall quality of life and sustainable economic development are the main objectives of a smart city (Oladunmoye, Obakin, 2023).

The topic warrants further research, as presenting new case studies can contribute to the ongoing development of the smart city concept and facilitate the implementation of tailored actions in diverse urban settings (Kummitha, 2019).

In the study, an evaluation was undertaken of a significant stakeholder in the smart city context, namely, the company. Taking into consideration fact, that in the literature the Citizen-Centric Smart City model is recommended (Lim et al., 2023), it might be worthwhile to broaden the groups of stakeholders and include citizens. This new group could provide additional insights into how other stakeholders understand a smart city, and the obtained results could be compared accordingly.

5. Summary

The primary objective of this paper was to advance the understanding of the relationship between company's level of knowledge on the smart city concept and its size. Addressing a research gap in association between company size and the knowledge about the smart city concept, this study sought to provide valuable insights.

A Kruskal-Wallis H test revealed no statistically significant difference in the level of smart city knowledge across the five analyzed groups based on company size. The average self-assessment of knowledge ranged from 59.8 for large companies to 67.8 for medium-sized

companies, with 100 indicating a comprehensive understanding of the smart city concept. This suggests that there is room for improvement in the general knowledge regarding the smart city concept, highlighting the need for actions related to knowledge sharing and the promotion of the concept.

The study results indicate no significant association between company size and the four selected statements regarding smart city concept. These statements encompassed ‘modern technologies used in the city’, ‘the city’s impact on improving the quality of life for its residents’, the city’s capacity for analyzing, monitoring, and utilizing data’, ‘the city’s commitment to working for the benefit of future generations’. Respondents predominantly agreed or strongly agreed with these statements. However, a question emerges regarding future research directions: With which characteristics entrepreneurs associate the smart city, if not with the usage of modern technology or a commitment to work for the benefit of future generations? The percentage of companies that do not associate the smart city with the selected statements ranged from 23% to 26%.

The study has notable limitations, primarily stemming from the restricted sample size and geographic scope. To overcome this, the authors recommend conducting the analysis with a more extensive sample size, covering all major cities in Poland, to enhance generalizability of the findings. Despite these limitations, the presented data can serve as a foundational basis for formulation a sustainable operation strategy, considering a pivotal factor: people, including entrepreneurs. The research outcomes carry significance not only for regional policymakers but also for researchers delving into the realm of strategic smart city development. As the perception of a city’s role undergoes transformation, the concept of a smart and sustainable city is gaining heightened importance, not only for municipal authorities but also for businesses. Implementing the smart city concept necessitates deliberate and thoughtful actions, fostering collaboration with all participants, particularly residents and businesses, who play active roles in the process.

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