Sustainable Development of European Smart Cities

International Conference on „Sustainable Development of European Smart Cities" – SmartEU 2023

Conferința Internațională „Sustainable Development of European Smart Cities"

9-10 IUNIE 2023, IAȘI, ROMÂNIA

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Jean Monnet Project “European Smart Cities for Sustainable Development” (SmartEU)
no. 620415-EPP-1-2020-1-RO-EPPJMO-MODULE

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ACKNOWLEDGEMENTS
This work was supported by Jean Monnet Module “European Smart Cities for Sustainable Development”—SmartEU, co-funded by the European Union (620415-EPP-1-2020-1-RO-EPPJMO-MODULE) and the Faculty of Economics and Business Administration, “Alexandru Ioan Cuza” University of Iași, Romania.

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

ISBN online: 978-606-714-781-0
ISBN print: 978-606-714-806-0

Coperta: Manuela Oboroceanu
Tehnoredactare: Florentina Crucerescu

700539 – Iași, str. Munteni, nr. 34, tel./fax: (0232) 314947
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SUSTAINABLE DEVELOPMENT OF EUROPEAN SMART CITIES
SmartEU 2023

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SmartEU 2023

June 9-10, 2023, Iași, Romania

EDITURA UNIVERSITĂŢII „ALEXANDRU IOAN CUZA" DIN IAŞI
2023

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SECTION 1

CHALLENGES ON MANAGING SMART AND SUSTAINABLE URBAN DEVELOPMENT

CULTURAL FACTORS FOR SUSTAINABLE URBAN DEVELOPMENT AT THE EUROPEAN UNION LEVEL

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Abstract: The cultural sector, a generator of creativity and innovation and a factor in enhancing community awareness and shared identity, contributes to more sustainable, connected and citizen-friendly urban environments. Sustainable development is a priority in EU policies, and exploring the cultural domain can add value by boosting cultural indicators as part of the development strategies. The paper's general objective is to analyze cultural indicators' influence on Sustainable Development Goals, especially in urban areas. The paper discusses the implications of the cultural domain in relation to Sustainable Development Goals (SDGs) with a focus on four of the goals: SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action). The analysis is based on national and city statistical datasets at the European Union level. The paper results are based on correlation and regression analysis, allowing us to make assessments on the role of the cultural domain in sustainable development. Using the XLSTAT software, a statistical analysis model was built based on the hypothesis that the SDGs' achievement level is influenced by the level of cultural development in the EU member states and cities. As a result, it was found that the achievement of the Sustainable Development Goals depends on the share of the cultural domain. In contrast, specific cultural infrastructures, activities and policies are closely linked to the notion of national and city development. Considering this, a policy approach including the cultural domain could support sustainable development.

Keywords: Sustainable Development Goals, Culture, urban sustainability, correlations

JEL classification: Q01, I28, I31, Z18

Introduction

The sustainability of human existence and activities has become a topic of central interest in academia and society, alongside fundamental economic and social issues. The concept of sustainable development has also gained considerable political influence. The relationship between nature, society, and the economy is at the heart of the issue. The concept itself was established worldwide with the report "Our Common Future" of the World Commission on Environment and Development (established in 1983 by the United Nations General Assembly), a document also known as the Brundtland Report (World Commission on Environment and Development, 1987). However, despite the achievements of recent decades, current concepts of sustainability and sustainable development are proving insufficient to lead the transitions needed to harmonise relations between people and the environment. The European Union (EU) is strongly committed to sustainable development and to being a leader in implementing the UN 2030 Agenda with its member countries. Sustainable development has been a fundamental

objective of the European Union since 1997, as it has been enshrined in Article 2 of the Treaty on the European Union (European Union, 1997). Sustainable urban development is significant for the overall sustainable development considering the high concentration of population, the need of resources efficiency as well as the complexity of challenges in addressing sustainability measures.

Lack of proper inclusion of culture is considered one of the factors that are responsible of the inefficiency of sustainable development policies failures in implementing well-intentioned programmes (UNESCO, 2012).

Culture is a multidimensional phenomenon affecting a country's economic activity as well as its social structure, beliefs and values. According to European Commission President Ursula Von der Leyen's narrative, "A Union striving for more: my agenda for Europe", the landscape, cultures and heritage are valuable characteristics for Europe reflecting its identity as well as its economic potential (European Commission, 2019). As "culture is a phenomenon that mostly 'happens' in urban areas" (Montalto, et al., 2019a), the paper approaches the cultural effects in the benefit of sustainable development from a dual perspective from national to cities level within the European Union. Cities are considered to be favorable units in terms of cultural transformations and catalysts for socio-economic development due to criteria such as the density of inhabitants, existing capital, increased accessibility and cultural dynamism, factors favorable to community development and measures to integrate culture into development strategies and governance processes. De facto, culture is a component of development (sustainable or not) influencing people and communities and creates conditions for balanced evolution.

The paper aims to analyze the level of influence of cultural indicators on the Sustainable Development Goals (SDGs), especially in urban areas. Based on the analysis of the relation between the cultural domain and SDGs, the article is based on a statistical analysis of the level of linkage between the SDGs and several cultural indicators at the level of the European Union as a way of identifying relevant cultural associations in the benefit of sustainable development.

1. Theoretical and policy foundations of Culture and Sustainable Development

The 2030 Agenda for Sustainable Development, adopted by all United Nations member states in 2015, provides a common background for the well-being of society and environmental protection. At its core are the 17 SDGs put in practice by a global partnership urging all nations to take collective action (United Nations, 2015). However, since the publication of the Brundtland Report, it has been noticed that fundamental factors such as environmental balance, economic growth and social equity do not fully respond to the complexity of the needs in the developing society.

The EU is perceived as a contribute factor in the progressive approach to the process of sustainable development. Policies to facilitate cultural input to sustainable development are highlighted with a focus on strengthening capacities for collaboratively meeting challenges and seizing opportunities for the benefit of European citizens. In particular, sustainable development was seen as a community objective in the countries of Europe. As set out in the document A New Strategic Agenda 2019 – 2024, the EU is committed to fostering sustainable development and contributing to implementing the 2030 Agenda (European Council, 2019), a long-term commitment highlighted in the EU Strategy for Sustainable Development (European Union, 2001). In the report "A Decent Life for All: From Vision to Collective Action" the European Commission recognized the need to build the framework to follow a sustainable path "to ensure a decent life for all by 2030" (European Commission, 2014). The importance of contributing to the achievement of the 2030 Agenda is underlined by the Council of the European Union (Council of the European Union, 2019a) alongside strengthening international

cultural relations and envisaging the potential of culture for sustainable development (Council of the European Union, 2018). Although not explicitly stated, EU cultural policies do make reference to the SDGs through policies, projects and related actions (Vila, Miotto and Rodríguez, 2021). For example, the cultural contribution to sustainable development is indicated at the EU level within the Council resolution on the Cultural Dimension of Sustainable Development (Council of the European Union, 2019b). The European Parliament points out the relevance of the cultural field for sustainable development in its report on EU action for sustainability, stressing the need of alignment of the policies that state the cultural factors integration within sustainable development with other international commitments (European Parliament, 2017).

The EU's approach to sustainable development involves its demographic diversity, population dynamism as well as changes in population structure as a result of migration, with cultural influences playing an important role and cultural aspects being both solutions and challenges. Considering the population density, economic activity, social inclusivity and multicultural background, cities play a significant role in sustainable development. The interest in the role of culture for urban change have increased greatly over the past two decades (Montalto, et al., 2019a) enhancing the role of culture for well-being and generating development opportunities. Culture is not only a fundamental component but also a driver towards a more sustainable society (Soini and Dessein, 2016) based on its ability to sustain social cohesion, community identity and awareness raising by facilitating shared norms and values for the society.

Urban environments are mainly characterized by diversity, culture being a connective factor of practices, languages and customs as well as a generator of cultural events and participation. Sustainable urban development fosters innovation and creativity as cities are beneficial places for artists and creative people, favorable spaces for co-creation, cooperation and showcasing, serving as potential catalysts for urban revitalization (Hrysenko, Pryiatelchuk and Shvorak, 2022). This correspondence highlights the capacity of culture to contribute to sustainable urban development, envisaging the sustainable cities as a desideratum of future urban development (Basiri, Azim and Farrokhi, 2017). Urban areas facilitate the formation and growth of creative clusters in favor of enhancing cultural vitality and fostering innovation, pursuing that such clusters contribute to urban regeneration (Dronyuk and Moiseienko, 2019). Moreover, the "creative class", characteristic that make cities creative, can act as a driver for urban regeneration (Florida, 2003). However, challenges to Florida's notion of the creative class and the associated mechanisms he posits for urban regeneration and growth were pointed by Pratt being underlined the need for a "reconceptualization of the role of culture in urban growth and change" (Pratt, 2008).

In terms of governance, as a supportive factor of sustainable urban development, "culture and cultural policies are becoming increasingly important and policymakers are using both to increase homogeneity in all spheres of society" (Sacco, Blessi and Nuccio, 2009). Moreover, people' receptivity for the cultural city life is an incentive for participatory policies and transparency measures in the decision-making process in reference to urban development (Katrin, 2020).

2. Methodology

Our study is based on a quantitative methodology including a statistical analysis of the variables. We performed an analysis in two levels, including the national and cities extent, based on specific variables. The two levels of the analysis include cultural related variables, six in the national level analysis and nine in the city level analysis, the Total score for SDGs and four of the SDGs. The methodology comprises correlation and linear regression statistical techniques between the cultural indicators and the included SDGs exploring if there is a relationship between the variables and the associations' degree.

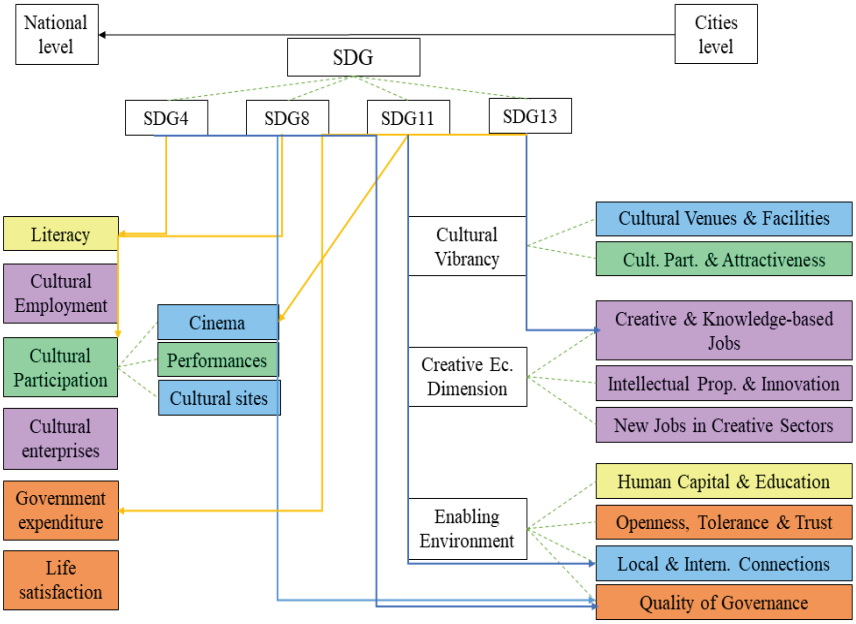


Figure 1: Variables, indicators, indexes, sub-indexes and dimensions included in the analysis and correspondences

Source: Authors' representation

Figure 1 indicates the variables, indicators, indexes, sub-indexes and dimensions included in the analysis at national and cities levels, the categorization and associations, as follows:

- Sustainable Development Goals, 2019 (indicated in blank):
  - SDG Index, SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), 2019.
- Education and human capital (indicated in yellow):
  - Literacy (Underachievement in reading, math or science), 2018;
  - Human capital & education, 2019.
- Cultural infrastructure (indicated in blue):
  - Frequency of participation in cultural or sports activities in the last 12 months by sex, age, educational attainment level and activity type: cinema, 2015;
  - Frequency of participation in cultural or sports activities: cultural sites (historical monuments, museums, art galleries or archaeological sites), 2015;
  - Cultural Venues & Facilities, 2019;
  - Local & International Connections, 2019.
- Cultural participation (indicated in green):
  - Frequency of participation in cultural or sports activities – total, 2015;
  - Frequency of participation in cultural or sports activities: live performances (theatre, concert, ballet), 2015;
  - Cultural Participation & Attractiveness, 2019.
- Cultural labor and enterprise (indicated in purple):
  - Cultural employment, 2019;
  - Number and the average size of enterprises in the cultural sectors, 2018;
  - Creative & Knowledge-based Jobs, 2019;

  - Intellectual Property & Innovation, 2019;
  - New Jobs in Creative Sectors, 2019.
- Governance (indicated in orange):
  - General government expenditure by function - cultural services, 2019;
  - Life satisfaction, 2018;
  - Openness, Tolerance & Trust, 2019;
  - Quality of Governance, 2019.

Data sources:

- National level analysis
  - Sustainable Development Goals: SDSN & IEEP, 2019. The 2019 Europe Sustainable Development Report. Sustainable Development Solutions Network and Institute for European Environmental Policy: Paris and Brussels.
  - Cultural indicators: Eurostat.
    Note: The indicator Low level in reading, mathematics or science is reflected in the analysis as Literacy in reading, math or science based on its transformation from a negative to a positive indicator.
- Cities level analysis
  - Sustainable development and Sustainable Development Goals: SDG index and dashboards for European Cities, 2019. Sustainable Development Solutions Network (SDSN) and the Brabant Center for Sustainable Development (Telos).
  - Cultural indicators: The Cultural and Creative Cities Monitor (Montalto, et al., 2019b). European Commission, Joint Research Centre.

The variables were selected as being relevant components of sustainable development, as they are closely linked to the economic, social, and environmental dimensions of sustainable development.

In terms of the cases included the analysis at national level includes the European Union member countries (28 member states - including the UK, an EU member country at the time of the statistical data) and the analysis at cities level includes 45 capital cities and large metropolitan areas in the EU and the European Free Trade Association (EFTA) according to SDG Index Dashboard data base.

The results were extracted using the statistical analysis program XLSTAT. Values marked in bold are statistically significant at the 0.05 threshold.

3. Cultural influences to sustainable development - a national approach

An analysis at the national level of European Union member countries (including the UK) was undertaken, as a first step in bridging national and urban levels for identifying overarching and complementary cultural factors as well as particularities and contextual specificity.

The hypothesis of the analysis is that the level of achievement of the Sustainable Development Goals is influenced by the level of cultural development in EU member countries.

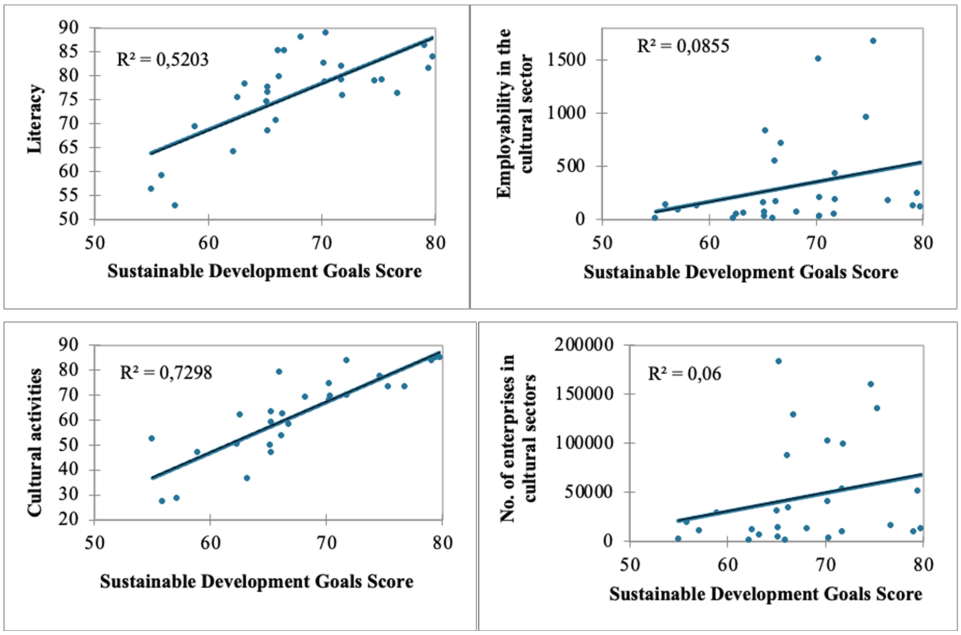
Table 1. Correlation coefficients between the cultural indicators and the SDGs (national level)

Variables	SDG Index	SDG4	SDG8	SDG11	SDG13
Literacy in reading, math or science	**0.721**	**0.813**	0.373	**0.541**	0.276
Employability in the cultural sector	0.292	0.144	0.156	0.309	**0.545**
Cultural activities	**0.854**	**0.817**	**0.729**	**0.826**	0.280

Variables	SDG Index	SDG4	SDG8	SDG11	SDG13
Cinema	**0.840**	**0.745**	**0.617**	**0.833**	0.353
Live performances	**0.705**	**0.782**	**0.651**	**0.723**	0.117
Cultural sites	**0.884**	**0.758**	**0.742**	**0.763**	0.391
Enterprises in cultural sectors	0.245	0.084	-0.041	0.177	0.497
Life satisfaction	**0.639**	**0.568**	**0.614**	**0.614**	0.221
General government expenditure - cultural services	0.386	0.108	0.158	0.328	**0.718**

Source: Authors' representation

As it can be noticed in Table 1, the cultural indicators of cultural activities (cinema, live performances, cultural sites), literacy in reading, math or science and life satisfaction show a strong link with the SDG Index. The level of association of SDG 4 presents the highest correlation value in relation to cultural activities, with a value of 0.817, but also literacy and life satisfaction have significant values. SDG 8 shows a strong correlation with the level of participation in cultural activities, with a value of 0.729. Also, the level of life satisfaction has a significant value. SDG 11 shows the strongest links with the cultural activities indicator with a value of 0.826, but a significant relationship is also identified with life satisfaction and literacy. As for SDG 13, it is associated with fewer indicators and shows weaker associations with the indicators, with a significant linkage with General government expenditure on cultural services with a value of 0.718 and with the level of employability in the cultural sector. Thus, with sufficiently high relevance, we can state that cultural indicators directly or indirectly, influence SDGs. Some cultures prohibit people from being open to new ideas and development (there are indigenous groups hampering the implementation of strategies) (Zheng, et al., 2021).



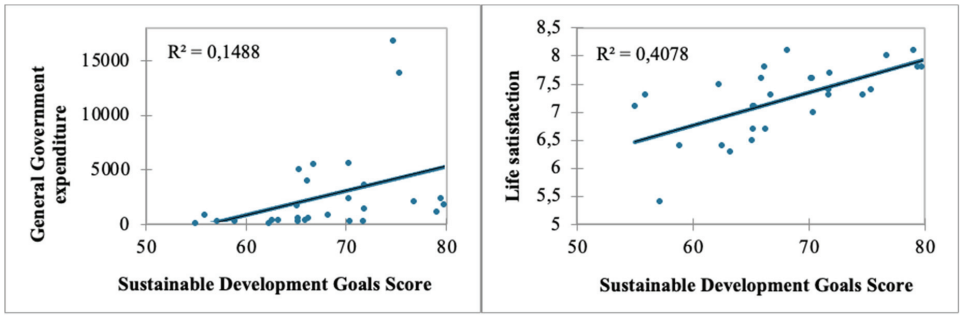


Figure 2: Linear regressions SDGs and cultural indicators

Source: Authors' representation

Figure 2 indicates that the total SDG score shows a positive linear relationship with cultural indicators. According to Figure 2, the cultural indicators of life satisfaction and the level of participation in cultural activities stand out with a correlation coefficient of 40.7% and respectively of 72.9% in relation to the SDGs, whereas the other indicators prove weaker correlation levels.

For an in-depth observation, a regression analysis was made, including the SDGs as dependent variables with the implication of the predictor variables, the cultural indicators.

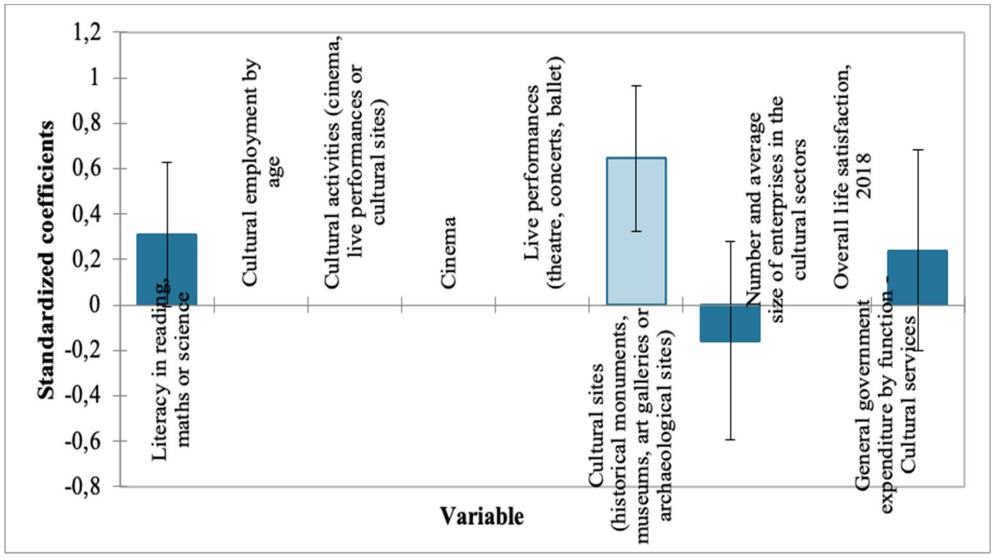


Figure 3: Dependent variable: SDG Index Score (0-100) / Standardized coefficients (99% conf. interval)

Source: Authors' representation

The best regression model includes four predictors: literacy in reading, math or science, frequency of participation in cultural or sports activities at cultural sites, enterprises in the cultural sectors and government expenditure on cultural services. The results of the regression analysis indicated that the cultural indicators explain 80.7% of the variance of the SDG achievement index (AdjR^2=0.807), a statistically significant percentage ($F(4,26)=28.148$; $p<.0001$). As it can be seen in the graph, among the cultural indicators, the strongest predictor

of the total SDG index is the frequency of participation in cultural or sports activities in cultural sites with a value of β= 0.645, p<.0001.

According to Figure 4, it is observed that the best regression model includes five predictors: literacy in reading, math or science; cultural employment; frequency of participation in cultural or sports activities at the cinema; frequency of participation in cultural or sports activities at live performances; general government expenditure on cultural services. The results of the regression analysis show that the mentioned cultural indicators explain 85.1% of the variance of the index of achievement of SDG 4 (AdjR^2=0.851), which is statistically significant (F(5,26)=30.663; p<.0001). Figure 4 shows that among the cultural indicators, the strongest predictor of the SDG4 index is literacy in reading, math or science, variable of education and human capital category, with a value of β= 0.514, p<.0001. It is noted the negative correlation of the indicator regarding government expenditure in culture and SDG 4 which might suggest that allocation of higher budget to education could lead to reduced government funding the cultural sector.

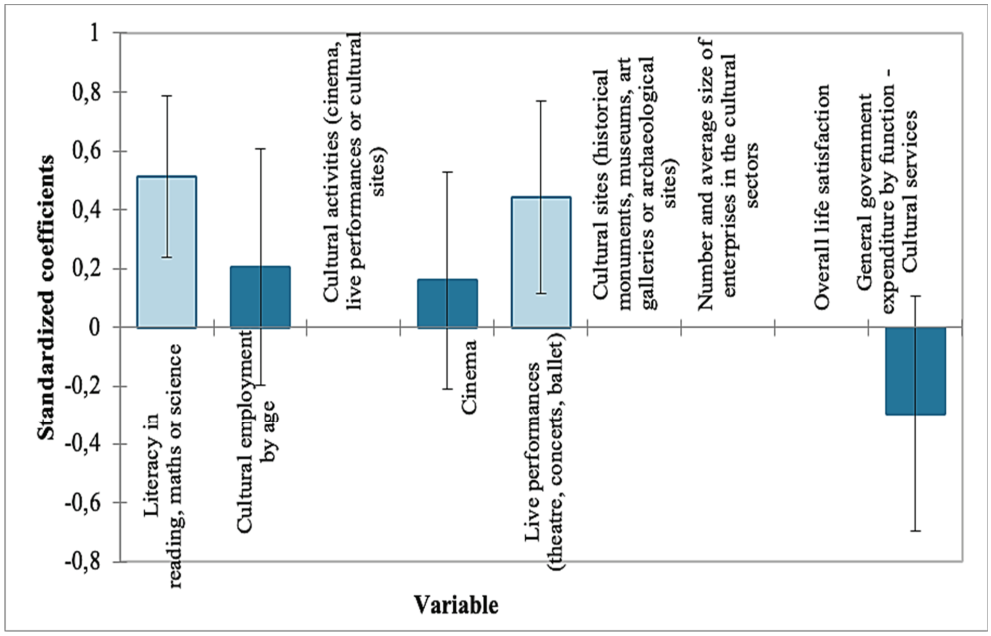


Figure 4: Dependent variable: SDG4 / Standardized coefficients (99% conf. interval)

Source: Authors' representation

Culture may represent a supportive factor in raising literacy levels by enhancing language skills and comprehension, embracing diversity, cultural education and intercultural awareness at all levels. Moreover, the educational contexts contribute to increased awareness at the level of peoples' behavior and foster society-wide perception towards sustainability (Katrin, 2020).

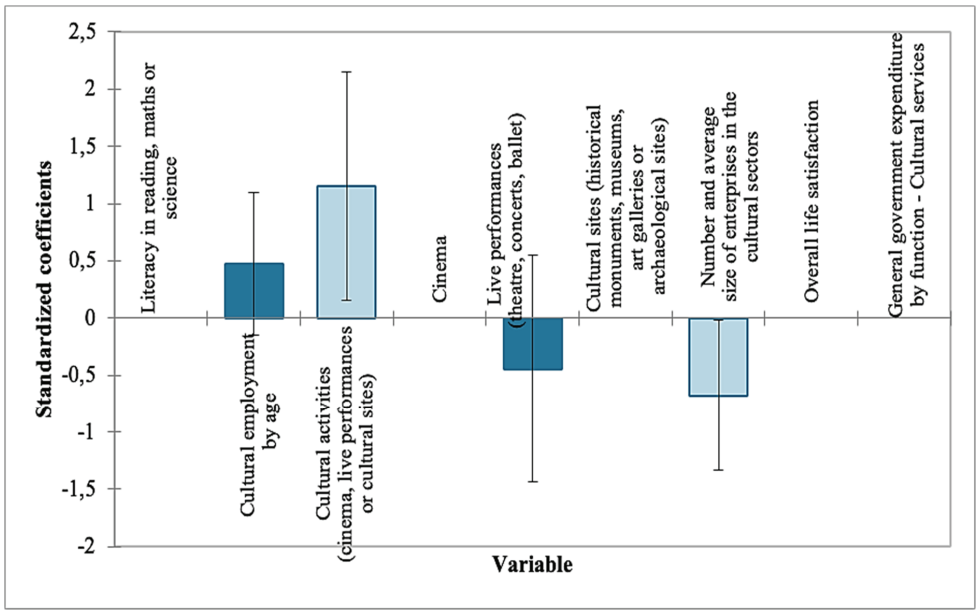


Figure 5: Dependent variable: SDG8 / Standardized coefficients (99% conf. interval)

Source: Authors' representation

Figure 5 presents that the best regression model includes four predictors of SDG 11: cultural employment; frequency of participation in cultural or sports activities - total; frequency of participation in cultural or sports activities at live performances; number and the average size of enterprises in the cultural sectors. The results of the regression analysis show that the mentioned cultural indicators explain 62.7% of the variance of the index of achievement of SDG 8 (AdjR^2=0.627), a statistically significant percentage (F(4,26)=11.919; p<.0001). Figure 5 shows that among the cultural indicators, the strongest predictor of the SDG 8 is the frequency of participation in cultural or sports activities - total, including cinema, live performances, cultural sites, variable of cultural participation category (with a value of β= 1.149, p<.004).

Cultural participation is boosted by cultural and creative industries that provide a supportive framework of cultural experiences and expressions. Cultural industries, creative arts and heritage are sources of investment into cities and regions, contributing to competitiveness advantage and economic growth (Duxbury, Kangas and De Beukelaer, 2017).

According to Figure 6 the best regression model includes five predictors: cultural employment; frequency of participation in cultural or sports activities - cinema; frequency of participation in cultural or sports activities at live performances; frequency of participation in cultural or sports activities - cultural sites; number and average size of enterprises in the cultural sectors. The results of the regression analysis show that the mentioned cultural indicators explain 73.1% of the variance of the achievement index of SDG 11 (AdjR^2=0.731), which is statistically significant (F(5,26)=15.134; p<.0001). Figure 6 shows that among the cultural indicators, the strongest predictor of the SDG11 index is the frequency of participation in cultural or sports activities – cinema, variable of cultural infrastructure category (with a value of β= 0.936, p<.001).

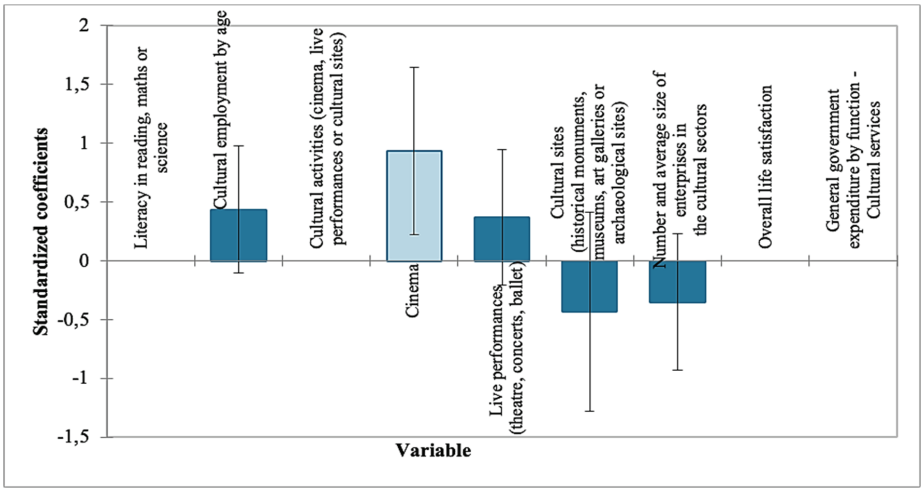


Figure 6: Dependent variable: SDG11 / Standardized coefficients (99% conf. interval)

Source: Authors' representation

The cultural landscape is thus a contributor to Sustainable Cities and Communities' Goal by shaping local identities, preserving cultural heritage, and boosting social practices and cultural manifestations. Fostering cultural participation brings a favorable input to community belonging and shared norms and values. "What is notable in the way that mainstream international agendas have dealt with tangible and intangible cultural heritage is its embedding in place, and particularly in relation to the aspiration of sustainable cities and communities" (Perry, Ager and Sitas, 2020).

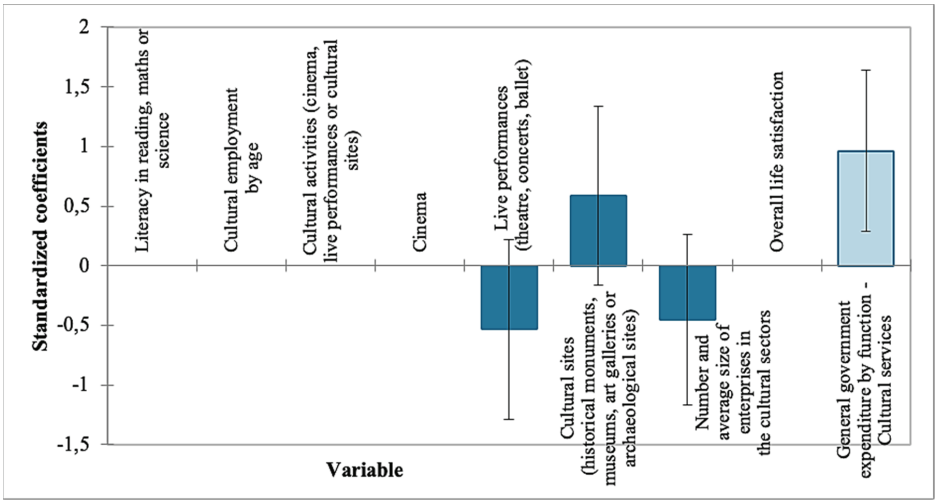


Figure 7: Dependent variable: SDG13 / Standardized coefficients (99% conf. interval)

Source: Authors' representation

As it can be observed in Figure 7, the best regression model includes four predictors: frequency of participation in cultural and sports activities - live performances; frequency of participation in cultural and sports activities - cultural sites; number and the average size of enterprises in cultural sectors; general government expenditure on cultural services. The results of the regression analysis show that the mentioned cultural indicators explain 55.0% of the variance

of the index of achievement of SDG 13 (AdjR^2=0.550), which is statistically significant (F(4,26)=8.942; p<.0000). Figure 7 shows that among the cultural indicators, the strongest predictor of the SDG13 - climate action is the level of general government expenditure on cultural services, variable of governance category (with a value of β= 0.962, p<.001).

Investment in cultural services is supported to collectively promote sustainable behaviors and raise awareness on climate action, encompassing both national and cities levels. The potential of culture in addressing societal challenges strengthened the use of instrumental policies of public expenditure for culture (Duxbury, Kangas and De Beukelaer, 2017). Culture may become thus a promoter of climate action and a generator of environmental education, knowledge and practices.

4. Culture's role within sustainable development – a focus on cities

Cities are often beneficial frameworks of rich cultural heritage, multicultural diversity, vibrant cultural manifestations and artistic expressions. Embracing culture as a factor of sustainable urban development may generate new opportunities and horizons of development. "The Sustainable Development Solutions Network estimated in 2016 that as much as 65% of the SDG agenda may not be fully achieved without the involvement of cities" (Lafortune, et al., 2019).

The paper includes a statistical analysis aiming to identify the level of influence of cultural variables on the achievement of the SDGs at the urban level within the European Union. The cities included in the analysis are 45 capital cities and large metropolitan areas in EU and EFTA. The hypothesis of the analysis is that the level of achievement of the SDGs is influenced by the level of cultural development in large EU cities.

Table 2. Correlation coefficients between the cultural indicators and the Sustainable Development Goals (cities level)

Variables	SDG Index	SDG4	SDG8	SDG11	SDG13
Index Score	**1**	**0.840**	**0.630**	0.397	-0.198
1. Cultural Vibrancy	0,256	0.393	0.128	0.201	-0.165
1.1 Cultural Venues & Facilities	-0,043	0.118	-0.077	0.040	-0.136
1.2 Cultural Participation & Attractiveness	**0,515**	**0.579**	0.322	0.321	-0.145
2. Creative Economy	0,346	0.313	0.413	0.129	0.167
2.1 Creative & Knowledge-based Jobs	0,346	0.237	0.186	0.103	0.173
2.2 Intellectual Property & Innovation	**0,570**	**0.590**	0.460	0.322	-0.043
2.3 New Jobs in Creative Sectors	-0,053	-0.016	0.272	-0.054	0.141
3. Enabling Environment	**0,583**	**0.615**	**0.524**	**0.529**	-0.332
3.1 Human Capital & Education	0,203	0.305	0.209	0.316	-0.075
3.2 Openness, Tolerance & Trust	**0,538**	0.473	0.493	0.341	-0.325
3.3 Local & International Connections	0,438	**0.515**	0.359	**0.588**	-0.285
3.4 Quality of Governance	**0,758**	**0.788**	**0.585**	0.481	-0.439

Source: Authors' representation

As presented in Table 2 among the correlations between SDG 4 and the Cultural and Creative Cities Monitor Sub-indexes, Enabling Environment with a value of 0.615 indicates the highest correlation value. We can state that there is a significant positive relationship between SDG4 and the dimensions of the Sub-index Enabling Environment, considering that the relation between SDG 4 and Quality of Governance of 0.788 indicates variables to be strongly correlated and it presents moderate correlations with Local & International Connections and Openness, Tolerance & Trust, with values of 0.515 and respectively 0.473. Among the dimensions of the sub-index Cultural Vibrancy, SDG 4 has significant positive correlations with Cultural Participation & Attractiveness with a value of 0.579. A weaker level of association is identified with the dimension of Cultural Venues & Facilities. In consideration of the sub-index Creative Economy, significant correlation is identified with the dimension Intellectual Property & Innovation with a value of 0.590.

Table 3. Correlation coefficients between the cultural indicators and the SDGs applied to selected cities in the EU regions

	Central and Eastern Europe:					Northern Europe:				
Variables	**Index Score**	**SDG4**	**SDG8**	**SDG11**	**SDG13**	**Index Score**	**SDG4**	**SDG8**	**SDG11**	**SDG13**
1. Cultural Vibrancy	0.695	0.843	0.368	0.704	-0.682	-0.737	-0.147	-0.032	-0.296	-0.874
1.1 Cultural Venues & Facilities	0.441	0.657	0.318	0.465	-0.530	-0.876	-0.658	-0.205	-0.145	-0.856
1.2 Cultural Participation & Attractiveness	0.745	0.797	0.321	0.737	-0.645	-0.471	0.271	0.106	-0.345	-0.697
2. Creative Economy	-0.005	-0.084	0.529	-0.179	0.357	-0.099	0.740	0.097	-0.462	-0.229
2.1 Creative & Knowledge-based Jobs	0.513	0.286	0.366	0.165	-0.202	0.196	0.879	0.257	-0.305	-0.039
2.2 Intellectual Property & Innovation	0.653	0.525	0.460	0.425	-0.057	-0.219	0.703	-0.585	-0.903	0.361
2.3 New Jobs in Creative Sectors	-0.552	-0.466	0.151	-0.459	0.485	-0.065	0.123	0.660	0.282	-0.795
3. Enabling Environment	0.756	0.638	0.158	0.689	-0.557	-0.740	-0.141	-0.042	-0.307	-0.868
3.1 Human Capital & Education	0.356	0.640	0.084	0.462	-0.375	-0.836	-0.381	-0.121	-0.250	-0.899
3.2 Openness, Tolerance & Trust	0.431	0.188	-0.060	0.308	-0.234	-0.488	0.227	0.118	-0.319	-0.730
3.3 Local & International Connections	0.725	0.588	0.332	0.721	-0.548	-0.835	-0.376	-0.119	-0.251	-0.900
3.4 Quality of Governance	0.874	0.684	0.513	0.718	-0.697	-0.426	0.597	-0.534	-0.909	0.051

	Southern Europe:					Western Europe:				
Variables	**Index Score**	**SDG4**	**SDG8**	**SDG11**	**SDG13**	**Index Score**	**SDG4**	**SDG8**	**SDG11**	**SDG13**
1. Cultural Vibrancy	-0.504	-0.081	-0.514	-0.209	0.202	0.484	0.424	0.584	0.033	0.122
1.1 Cultural Venues & Facilities	-0.792	-0.297	-0.678	-0.092	-0.370	0.386	0.253	0.524	-0.084	0.223
1.2 Cultural Participation & Attractiveness	0.218	0.254	0.055	-0.215	0.801	0.545	0.596	0.577	0.193	-0.037
2. Creative Economy	0.334	0.568	0.013	0.256	0.546	0.523	0.306	0.522	0.153	0.125
2.1 Creative & Knowledge-based Jobs	0.359	0.551	0.015	0.365	0.486	0.562	0.161	0.418	-0.083	0.307
2.2 Intellectual Property & Innovation	0.468	0.446	0.597	0.437	0.083	0.348	0.314	0.330	0.160	0.092
2.3 New Jobs in Creative Sectors	0.132	0.384	-0.157	-0.015	0.511	0.292	0.352	0.523	0.426	-0.202
3. Enabling Environment	0.723	0.674	0.674	0.537	-0.033	0.186	0.200	0.763	0.424	-0.241
3.1 Human Capital & Education	0.430	0.545	0.165	0.686	0.023	0.119	0.101	0.534	0.125	0.094
3.2 Openness, Tolerance & Trust	0.456	0.308	0.743	0.058	-0.173	0.084	0.063	0.555	0.339	-0.417
3.3 Local & International Connections	0.695	0.535	0.298	0.507	0.257	0.199	0.322	0.428	0.589	-0.242
3.4 Quality of Governance	0.226	0.428	0.336	-0.228	0.128	0.419	0.600	0.573	0.492	-0.403

Source: Authors' representation

SDG 8 presents significant positive correlations with the Sub-Index Enabling Environment with a value of 0.524, and among the component dimensions, the Quality of Governance is noticeable with a value of 0.585. A weak negative relation is identified with the dimension Cultural Venues & Facilities, with a value of -0.077.

SDG 11 is identified with significant positive correlations with the Sub-Index Enabling Environment with a value of 0.529. Among the component dimensions, it is notable the correlation with Local & International Connections with a value of 0.588 and moderate correlation with Quality of Governance with a value of 0.481. A weak positive correlation is noticed with the dimension Cultural Venues & Facilities, with a value of 0.040.

SDG 13 is remarked as presenting negative correlations with several variables. Among these, the variable SDG13 and the Sub-index Enabling Environment have the highest value of –

0.332, and among the dimensions, Quality of Governance is found to be the highest negatively correlated with the SDG13 with a value of -0.439.

Thus, we can state that there is a significant positive relationship between the analyzed SDGs and the Sub-Index Enabling Environment, mostly with the dimension Quality of Governance and a moderate negative relationship between the SDG13 and the Sub-Index Enabling Environment, and mostly with the dimension Quality of Governance.

The analysis on the EU regions presents significant correlations among the variables for cities in Central and Eastern Europe, with the highest positive values among the SDG 4 and the cultural predictors and the highest negative relation among the SDG 13 and the cultural predictors. In Northern Europe, it is mostly noted higher positive correlation values between SDG 4 and the cultural predictors and negative significant correlation values between SDG 13 and the cultural predictors. Moderate correlation values are identified in Southern and Western Europe.

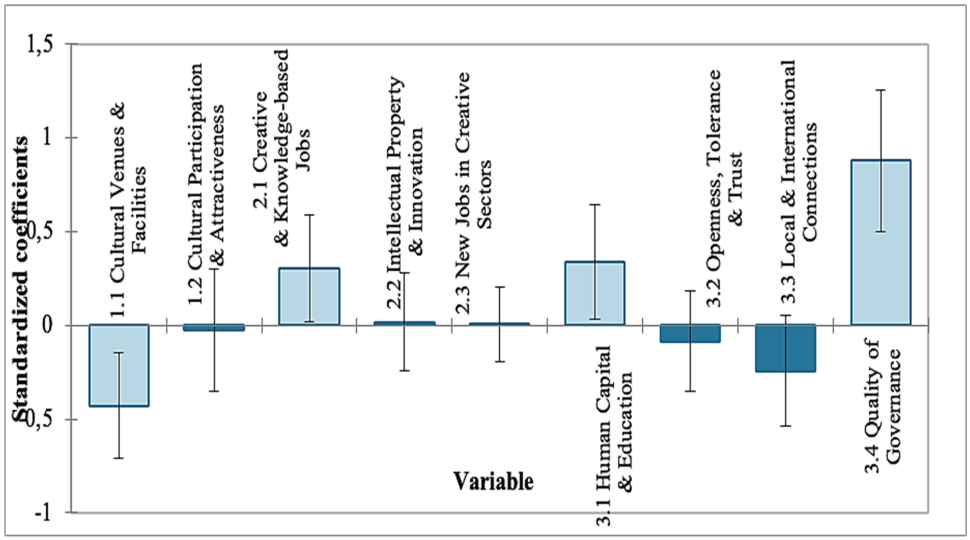


Figure 8: Dependent variable: Index Score / Standardized coefficients (95% conf. interval)

Source: Authors' representation

As presented in Figure 8, the best regression model includes four predictors: Cultural Venues & Facilities, Creative & Knowledge-based Jobs, Human Capital & Education, Quality of Governance. Among the explanatory variables, Quality of Governance, variable of governance category, is the most influential. The results of the regression analysis indicate that the nine cultural indicators explain 62% of the variance of the SDG Index Score ($AdjR^2$= 0.623), a statistically significant percentage ($F(9,44)=9.091$; $p<.0001$).

Culture's presence within sustainable urban development leads to creative cities embedding economic, social and political factors (Vitkova and Silaci, 2019), stressing participatory decision-making processes for the benefit of community cohesion. The concept of smart cities tackles sustainability issues by several means including citizen engagement, efficiency measures and the governance system (Basiri, Azim and Farrokhi, 2017). Moreover, cultural governance is based on shared responsibility, promoting dialogue and cooperation among decision-makers and cultural stakeholders.

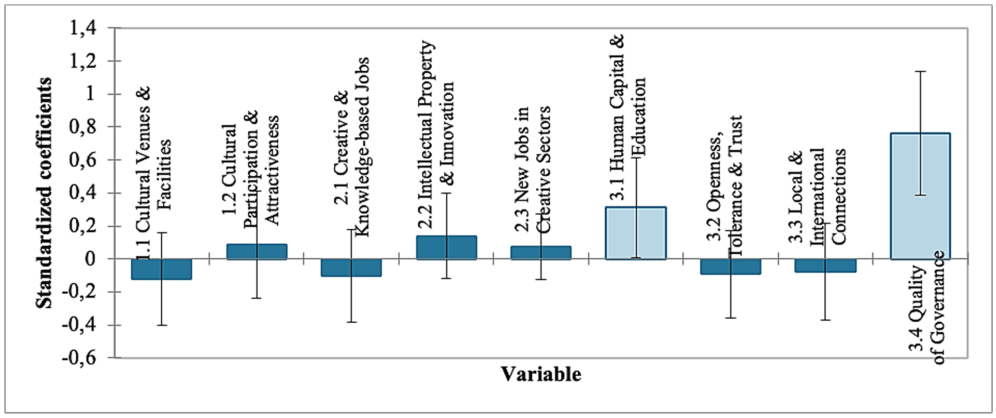


Figure 9: Dependent variable: SDG4 / Standardized coefficients (95% conf. interval)

Source: Authors' representation

As presented in Figure 9 the nine cultural predictors included in the analysis explain 62% of the variance of SDG 4 (AdjR^2= 0.628), a statistically significant percentage (F(9,44)=9.249; p<.0001). Among the variables, the best model includes the predictors Human Capital & Education and Quality of Governance, with the variable Quality of Governance being the most influential.

Quality of governance facilitates inclusive education and cultural awareness based on the involvement of cultural entities and actors as well as participation opportunities created and promoted at the societal level by cultural stakeholders. Human capital and quality of governance become, in this context, enablers of sustainable urban development through increased knowledge and skills of community engagement.

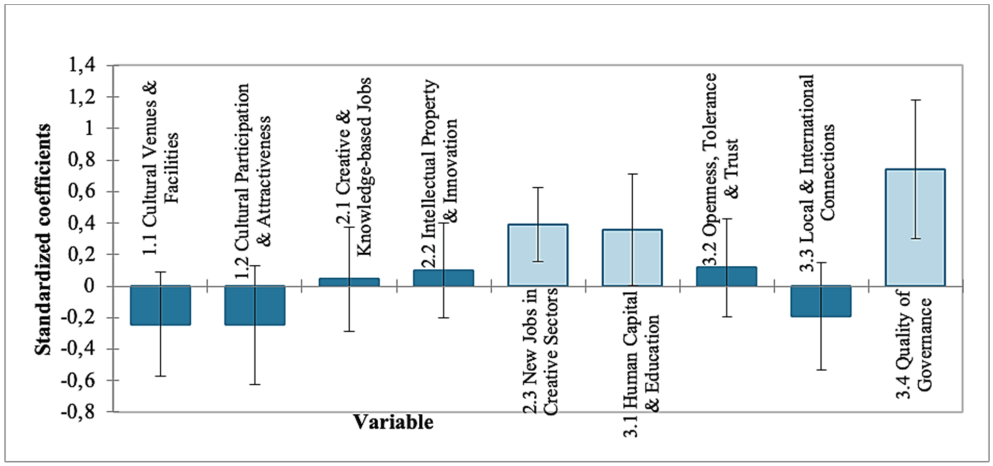


Figure 10: Dependent variable: SDG8 / Standardized coefficients (95% conf. interval)

Source: Authors' representation

According to Figure 10, given the AdjR^2, 49% of the variability of the dependent variable SDG8 is explained by the nine explanatory variables. The indicators that bring significant information are New Jobs in Creative Sectors, Human Capital & Education and Quality of Governance, the variable Quality of Governance being the most influential. The results of the

regression analysis explain 49% of the variance of the SDG8 (AdjR^2= 0.491), (F(9,44)=5.724; p<.0001).

Efficient use of governance tools could contribute to comprehensive policies answering the sustainable cities' development challenges by valuing the cultural landscape and creative sectors' capacities. In a governance process based on the cities' actual needs, local and cultural contexts shall be taken into consideration by urban planners and governments aiming at the sustainable development goals achievement (Chen, 2023).

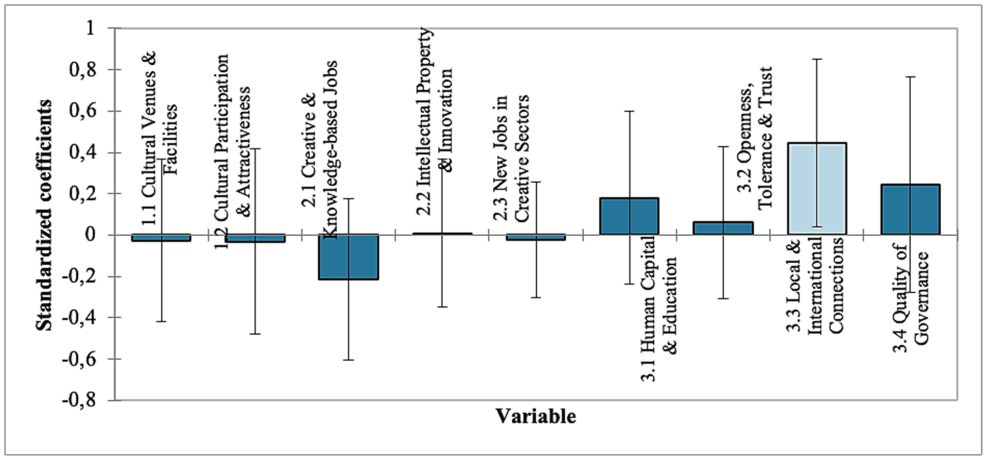


Figure 11: Dependent variable: SDG11 / Standardized coefficients (95% conf. interval)

Source: Authors' representation

Figure 11 illustrates that 28% of the variability of the dependent variable SDG11 is explained by the nine indicators of the analysis at the cities level. The indicator that brings significant information to explain the variability of the variable SDG11 is Local & International Connections, variable of cultural infrastructure category. The results of the regression analysis explain 28% of the variance of the SDG11 (AdjR^2= 0.283), (F(9,44)=2.927; p<.0011).

Local and international connections facilitate the exchange of knowledge, ideas and practices, as well as collaboration between stakeholders. Smart cities should reflect stakeholders' cooperation in the identification and prioritization of public policies in the interest of the community (Helbing, et al., 2021).

According to Figure 12 the nine cultural predictors explain 30% of the variability of the dependent variable SDG13. The best model includes the variables Cultural Venues & Facilities and Creative & Knowledge-based Jobs. Variable Creative & Knowledge-based Jobs, component of cultural labor and enterprise category, is the most influential. The results of the regression analysis explain 30% of the variance of the SDG13 (AdjR^2= 0.307), (F(9,44)=3.164; p<.007). It is remarked the preponderant reverse correlation of the variables which might suggest that at cities level the climate challenges are negatively associated with the cultural aspects. This might be generated by factors such as infrastructure investments, differentiated funding allocations, excessive transportation usage, exploitation of green spaces or even conflicting values and governance priorities regarding cultural needs over climate-related actions. The highest negative correlation with Quality of governance may lead to the perception that urban governance it is not yet sufficiently oriented towards climate action.

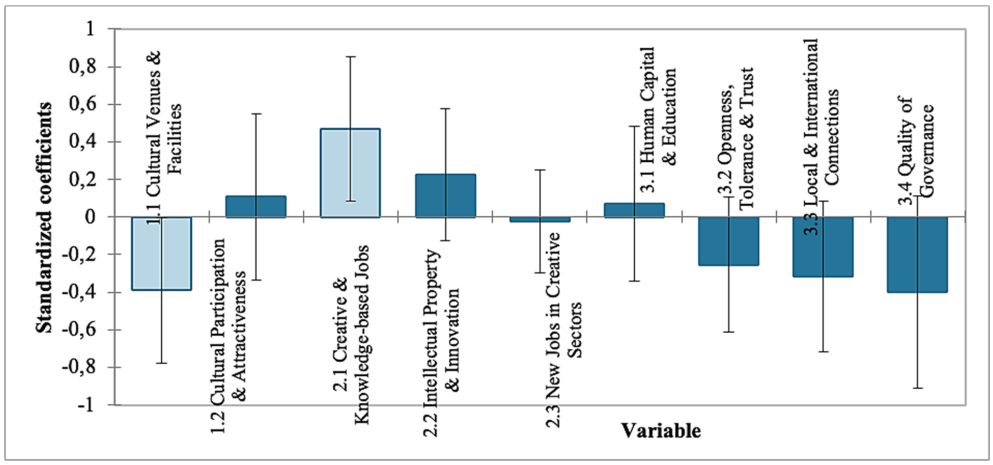


Figure 12: Dependent variable: SDG13 / Standardized coefficients (95% conf. interval)

Source: Authors' representation

Factors such as protection of the environment, employment, social infrastructure and basic services are contributively to sustainable city development (Fayomi, et al., 2019). The cultural and creative sectors features, by their agglomerated nature, bring advantages to urban efficiency such as attraction of people and production factors as well as increased productivity (Cerisola and Panzera, 2021).

5. The implications and the limits of the multi-scale approach

The paper brings an integrated perspective of cultural related indicators under the umbrella of sustainable development at national and city level facilitating the understanding based on differences and similarities. Addressing the level of associations among cultural indicators and the SDGs in a multi-scale analysis brings an increased level of understanding of the cultural factors that contribute to sustainable development.

In consideration of the multi-scale dimensions included in the analysis it is noted that:

SDG4 were identified high values of prediction given by education and human capital category variables at national level and governance at cities level. Among the selected SDGs included in the study, SDG 4 has highest values of correlations of the cultural indicators at both national and city level stages. This indicates that the relationship between education and culture is complex and multifaceted and that culture is a contributor to supporting endeavors in ensuring quality education for all at levels.

SDG8 is higher influenced by cultural participation and governance categories variables at national and respectively, city scale. In this consideration it is underlined the potential of cultural sectors to create employment opportunities and contribute to economic growth considering as well the place-based differences in terms of economic development. The governance system shall be regarded as a key aspect in generating cultural incentives and action plans favorable to SDG8 targets as well as the importance of cultural stakeholders' engagement in decision-making processes.

SDG11 has higher levels of prediction given by the cultural infrastructure category variables, including participation in cultural activities in cultural sites (historical monuments, museums, art galleries or archaeological sites), cinema at national level, and local and international connections at cities level. This stresses the relevance of cultural facilities and heritage for

sustainable cities and communities as well as the importance of facilitating access to cultural spaces and manifestations for boosting social cohesion and culturally vibrant cities.

SDG13 indicates as higher dependence values on governance and cultural labor and enterprise categories at national and respectively, cities levels. It is noted that SDG 13 indicates negative values which underlines the importance of resources allocation planning which shall consider the interrelation of climate and cultural factors and that limitations on one side might affect other components and rather than creating a dichotomy among the two dimensions, synergic policies shall be approached.

In terms of particularities, it is observed a differentiation among regions within the cities level analysis in consideration of the cultural indicators association level with the SDGs. Such a perspective brings an informational input in understanding the cultural contexts that influence sustainable development and the needs of alignment and tailoring the policies of intervention to the societal challenges in accordance with the geographical boundaries and localized challenges and solutions.

The diversity of the cultural related indicators included in the analysis underlines the cross-sectional influences of the cultural domain and its multiple reverberations at societal level. The analysis results point out the interconnectivity among culture and the SDGs achievement and the importance of citizens and stakeholders engagement alongside decision makers' responsiveness in the governance processes. Moreover, as urban areas grow and face new challenges, analyzing the connection between culture and the SDGs draws attention to the potential benefits of cultural elements integration into sustainable urban development.

Through the methodology approached the paper's results are subjected to several limitations. The statistical analysis is based on secondary data collected from different data sources that brings a high range of complexity in the data analyzed including cultural related indicators and the four of the SDGs selected. Moreover, the complexity is given by the two levels of the analysis, at the national and the cities level which emphasizes the data variability and the need of differentiation between significant and less significant data.

Other limitations are related to the geographical scope, the number of cases and time references included in the official data sources identified. The analysis at national level includes 28 cases (consisting in the number of the member countries of EU at the time of the data analyzed) and the analysis at cities level includes 45 cases (consisting in capital cities and large metropolitan areas in EU and EFTA).

Conclusions

The role of culture in sustainable development is underpinned by its complex system of values and creative potential, fostering social cohesion and providing economic effects, all of which are, in turn, reflected in well-being and future-oriented development measures. Culture is about people's actions, and it acts as a catalyst for social dialogue, an economic driver and an environment protection promoter. The cultural contribution is an investment in sustainable development while acting as a social bond for the community, developing horizons and strengthening the governance process. As "national and local economies can be regenerated through the cultural industries" (Hesmondhalgh and Pratt, 2005), it is critical to ensure that economic growth is inclusive and that everyone has access to the benefits of development. From an urban perspective, "the sustainable city is a city which in terms of sustainable urban development, economic growth, income and employment can fulfil the needs of its citizens" (Basiri, Azim and Farrokhi, 2017, p.79).

The current study presents in a structured way the statistical analysis of the links between the cultural and Sustainable Development Goals variables. By analyzing the influences of the

cultural indicators on sustainable development, it can be seen that these variables provide significant effects, and there are statistical links between the indicators included. In terms of the representativeness of cultural indicators, it is observed that the indicator comprising the frequency of participation in cultural activities has the highest correlation with the SDGs Total Index. At the national level analysis, participation in cultural activities (cinema, live performances, and cultural sites) is identified as a common favorable indicator of the benefit of the SDGs, followed by the indicators of literacy in reading, math or science and life satisfaction. At the city-level analysis, it is identified as the most favorable indicator the quality of governance followed by intellectual property & innovation, openness, tolerance & trust and cultural participation & attractiveness.

As common categories at both national and city level were identified to be governance and the cultural infrastructure whereas cultural labor and enterprise, education and human capital and cultural participation categories were identified differently in the levels of the analysis, national or cities.

There is also a differentiation of the predominant cultural indicators according to the specifics of each Sustainable Development Goal included in the analysis. Thus, it can be seen that the cultural pillar is relevant both for sustainable development as a whole and in relation to the SDGs, making a positive contribution to achieving the goals. We emphasize that participation in cultural activities is correlated with SDG4 as well as a generator of employment favorable to SDG8. Participatory governance and engagement through culture are as well favorable to SDG4 and SDG8. Cultural infrastructures envisaging cultural sites and accessibility facilities are assigned to SDG11 while government investments and creative jobs and knowledge based are potential contributors to SDG13. Among the cultural indicators, the participation in cultural activities at the national level analysis and the quality of governance at the city level analysis are seen as prevalent in the SDGs, therefore emphasizing the importance of citizens' engagement, connectivity and shared experiences.

The analysis carried out highlights that there is a significant link between cultural indicators and the achievement of Sustainable Development Goals, thus underlining the importance of the cultural dimension for sustainable development from a social, economic and environmental perspective, with a focus on the urban level. In conclusion, with sufficiently high relevance, we can say that Culture influences sustainable development providing a beneficial framework for the overall well-being.

The study reiterates the need for in-depth analyses of culture as a component that influences sustainable development to generate new information that can be of interest to other researchers involved in exploring the factors that can affect Sustainable Development Goals as well as to policymakers.

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SUSTAINABLE BEHAVIORS MAKE A CITY SMART: AN INQUIRY INTO CONSUMERS' PERCEPTION OF SUSTAINABLE COSMETIC BRANDS

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Abstract: Modern-day cities are human-centric, focusing on smart living and well-being. Sustainable living involves three pillars – economic, social, and environmental – and represents a goal for the city's development. The principles of sustainability have permeated the industry of cosmetics, with many corporations putting considerable effort into adopting sustainable practices and delivering better products. Generally, consumers buy cosmetic products according to hedonic and utilitarian reasons but also as a symbol of social prestige. Those who are sensitive to sustainable policies tend to trust the brands that implement them and make their purchasing decisions accordingly. Our exploratory study investigates whether there are differences between female and male customers in terms of perception of sustainable cosmetics brands (SCB). We collected data from consumers through an online questionnaire via social media, using an online survey platform. Thus, the snowball sample consists of 288 valid responses from male (50%) and female (50%) consumers of SCB. Because we were interested in comparing the female and male groups of sustainable brand customers, this ratio in our convenience sample was a precondition. We tested eight variables that received particular attention in the literature: brand attachment, brand authenticity, brand trust, corporate credibility, intention to join a brand page, social prestige, resilience to negative information, and purchase intention. We performed a Mann-Whitney U test to assess group comparison, and the findings show meaningful differences in perception of brand authenticity and intention to join a brand page. The results contribute to the literature and have a series of managerial implications.

Keywords: sustainable living; sustainable cosmetics brands; male-female perception differences; brand authenticity; intention to join a brand page; social prestige; purchase intention

JEL classification: M37

Introduction

"Cyber cities" are places where the citizens "are called to play a crucial role as co-designers and actuators of urban developments" (Scardovi, 2021, p. 10). Sustainable living means upgrading the quality of life for the present citizens and ensuring that future generations will benefit from necessary resources. "The triple bottom line" (Elkington, 1997) remains a pivotal guideline for governing a city, with economic, social, and environmental policies and

strategies. Also, smart cities support sustainable development (Estevez, Lopes and Janowski, 2016). Improving the quality of life for the citizens and ensuring that next generations will benefit from necessary resources represent a goal for contemporary cities. A "sustainable lifestyle" (Cohen and Dong, 2021) encompasses a multitude of behaviors (e.g., consumption). On the one hand, behaviors may involve people respecting social norms, such as recycling paper, preserving energy or sticking to socially acceptable levels of energy consumption, or practicing selective waste collection. On the other hand, as Minton et al. (2018) argue, we witness the presence of sustainable behaviors that are chosen for self-enhancing reasons, such as purchasing organic or recycled products. Evidently, this distinction is a very subtle one, as it is often the case that people adhere to individual, self-imposed norms. In this respect, our paper investigates this micro-level of perceptions and behaviors that shape the actual lifestyle of the citizen and that also contribute to the sustainability of the smart city.

Cosmetic consumption behaviors and how people perceive them constitute a key component of a sustainable lifestyle. For individuals, cosmetics represent a necessity, a pleasure, a sign of prestige, or a daily ritual. On the one hand, many consumers are becoming more sensitive to sustainability policies and actions; on the other hand, others are still uninformed or unaware of the corporate messages related to sustainability. Moreover, traditionally, cosmetics have been perceived as a feminine domain of interest. Even if the role of male and female buyers changed over time and gender neutrality seems to constitute a trend for the future of cosmetics, the actual situation still needs a gender segmentation for a better understanding of cosmetics use (Ulrich and Tissier-Desbordes, 2018). Also, most cosmetic brands remain gendered, and the same goes for advertisements, which usually contain either feminine or masculine cues. Moreover, women are heavy consumers of cosmetic products, but they are also the most involved in sustainable consumption. This disproportionality represents a real sustainability gender gap, with negative outcomes in terms of progress. There is a strong correlation between sustainability and femininity, also visible in ads. This labeling could lead to male resistance to sustainable cosmetics brands (SCB) because "green is the new pink" (Bennett and Williams, 2011, p. 52). Moreover, men are generally less likely to buy and use sustainable brands. Brough et al. (2016) discussed a "green-feminine stereotype", held by both men and women that contributes to the men's avoidance of sustainable behaviors to preserve a "macho image" or simply to affirm their different masculinity. Thus, the association between femininity, greenness, and sustainability seems to be a threat to consumers that want to maintain a masculine gender identity ("gender-identity maintenance"). This stereotype indicates that consumers will behave differently according to the association made with diverse gender cues; "masculine branding" could be a solution to gain men to the sustainable philosophy. Pro-environmental behaviors were considered feminine (Kennedy and Kmec, 2018), but gender-bending is also possible (Swim, Gillis and Hamaty, 2020). At the same time, there is a new Generation S of teens (i.e., Generation Sustainability) who do not manifest the same feminine association with the sustainability movement. They are "green natives" and have embedded sustainable values in their lifestyles, irrespective of the gender of their target market (Bennett and Williams, 2011). As the literature review depicts, gender still shapes people's attitudes toward sustainable products, brands, and companies (Obermiller and Isaac, 2018; Pinna, 2020). Not only male–female group differences are at work, but also the stereotypes and norms continue to influence the modalities in which consumers perceive sustainability and consumption (Bloodhart and Swim, 2020).

Therefore, this paper examines whether there are dissimilarities between male and female consumers concerning the perception of SCB. Our study is constructed as follows: in the next section, we review the significant literature, and we propose the research hypotheses. After that, we present the research methodology, and we discuss the results. The last part depicts the conclusions, with an emphasis on the theoretical gain and practical implications, as well as the limitations and future research directions.

Literature review

1.1. Brand attachment

Brand attachment constitutes a "longer-lasting, commitment-inducing bond between the brand and the consumer" (Esch, et al., 2006) and a key predictor of purchases. For better outcomes, brand knowledge is not sufficient if it is not doubled by brand relationships. Also, people's attachment to a certain SCB could be interpreted as a sign of trust that the brand will be constantly able to fulfill their expectations. Brand attachment proved to be strongly linked to brand experience for hedonic brands while for utilitarian brands, brand experience is strongly connected to brand trust (Huaman-Ramirez and Merunka, 2019). When customers are emotionally committed to a brand, their intentions to buy it increase considerably. Brand satisfaction and brand trust have a positive effect on the development of attachment. Brand attachment is explained both as a catalyst of brand trust (Loureiro, Ruediger and Demetris, 2012) and as a consequence of brand trust (Huaman-Ramirez and Merunka, 2019). Based on general attachment theory, Thomson et al. (2005) revealed that eagerness to pay a premium price is consistent with attachment to brands. The stronger the customers' attachment to the brand, the higher the capacity to forgive various misbehaves of the brand and to underestimate brand competitors. There are six determinants of brand attachment (self-congruence, quality, reputation, experience, responsiveness, and trust) and three types of outcomes (intent of recommendation, purchase or revisit; resilience to negative information; standing up for the brand) (Japutra, Ekinci and Simkin, 2014).

Gender differences in "attachment style" could be generated by the various ways in which female and male consumers perceive their relationship with brands. While males conceive this relationship as one-way, females consider this relationship as being dual. For the latter, the way brands "behave" and communicate with them becomes a meaningful criterion (Monga, 2002). Therefore, we propose the following non-directional research question:

RQ1: Is there a difference between the SCB attachment of female and male customers?

1.2. Brand authenticity

Consistent research has proven that brand authenticity shapes emotional brand attachment and word-of-mouth (Morhart, et al., 2015), brand relationship quality (Fritz, Schoenmueller and Bruhn, 2017), brand trust, perceived quality, and cultural iconicity (Södergren, 2021). Genuine brands create a meaningful connection with customers on both symbolic and emotional levels that shape their identity and self-authentication. Actually, brand authenticity encapsulates more than one issue. On the one hand, we have the problem of identifying the real from the fake. On the other hand, brand managers try to show that their products are genuine, original and represent a form of heritage. The fact that people consistently perceive some brands as having these qualities led to the inclusion of brand authenticity among the important traits of branding architecture. Being perceived as authentic thus becomes a form of competitive advantage (Guèvremont and Grohmann, 2016). Nowadays, consumers not only search for good products with a fair price, but they want those products to reflect their self-image, expectations, and life philosophy. When a product is perceived as fake or artificial, people might step away from that brand (Gilmore and Pine, 2007). The importance of brand authenticity is evident to companies, but building it constitutes no easy task.

Conceptual determination of what is "really authentic" is a serious semantic problem, with authenticity being perceived today as a construct rather than a thing in itself. This is also seen in the efforts of developing brand authenticity measurement scales (Morhart, et al., 2015). Brand authenticity perceptions depend on iconic and indexical cues, but also on existential ones. Uniqueness, scarcity, longevity, and longitudinal consistency determine a brand to be

perceived as authentic (the first two elements are linked to rarity, while the last two are to stability) (Moulard, Raggio and Folse, 2016). Consumer-brand relational authenticity should be also considered. Relational authenticity proves to be different from attachment, trust, and commitment (which act as moderators) and influences both brand attitude and purchase intention (Ilicic and Webster, 2014). The postmodern consumer faces a hyperreal world built by the marketing industry. This triggers a lack of faith in marketing campaigns and a subsequent search for authentic products. In this context, a deeper understanding of consumer motives and behaviors (such as opting for non-mainstream brands or for developing new buying habits) constitutes a necessary action for brand managers.

In the cosmetics sector, the issue of brand authenticity elicits questions regarding global versus local products, country of origin, and heritage or "fauxthentic" products. Bruhn et al. (2012) refine the conceptualization of brand authenticity as: "continuity", "originality", "reliability", and "naturalness". Hedonism surpasses utility as a core value when it comes to authentic cosmetics. There is a difference between indexical and iconic authenticity: while both signify emotional value, the former is closely linked to quality, and the second to social value. Perceived authenticity produces emotional benefits which influence purchase intention (Lee, 2020), with the help of a good brand narrative. Very few studies discussed gender differences related to the perception of brand authenticity (Arora, et al., 2016). In this vein, our study intents to shed some light on this unchartered issue. Thus, we propose the following non-directional research question:

RQ2: Is there a difference between female and male customers regarding the perception of SCB authenticity?

1.3. Brand trust

Delgado-Ballester and Munuera-Alemán (2001) identify brand trust as being the sentiment of security regarding the capacity of a certain brand to raise to the expectation of the clients. Brand trust proves to have relevant effect on consumer commitment, mediated by the variable of customer involvement. The work of Chaudhuri and Holbrook (2001) represents a hallmark in the brand trust study. They bring up both utilitarian and hedonic values (largely used afterward in literature) and analyze 107 brands, including cosmetic brands. The link between perceived brand value and brand trust is stronger for customers who have serious knowledge about sustainability (Park and Kim, 2016). This proves to be very important since it confirms, at least partially, the intuition according to which customers who actively seek or stumble across sustainability information will form a stronger relationship with the brand. Studies have been made concerning green brand trust and the relevance of the subsequent corporate practices in the field of cosmetics (Lee and Chen, 2019).

Women tend to be more socially oriented than men, so they seem more trusting (Huaman-Ramirez and Merunka, 2019). The relationship with a brand mirrors, up to a certain point, a relationship that we develop in our social life. Henceforth, a positive experience with a brand triggers bigger levels of trust in women. Gender moderates between brand trust and behavioral loyalty and between attachment and attitudinal loyalty (Sivarajah and Sritharan, 2014). Considering these studies, we propose the following non-directional research question:

RQ3: Is there a difference between female and male customers regarding trust in SCB?

1.4. Corporate credibility

The modalities in which a company is perceived have an essential role in the development of people's attitudes about it, its reputation and purchase intention. These perceptions also form a generic image of the company, indicating how consumers feel about the respective corporation.

Corporate credibility is typically conceived as a similar form of spokesperson's credibility, even if there are many differences between them. For a person, a company is credible if it is reliable, believable, and trustworthy. Corporate credibility was defined as "the extent to which consumers feel that the firm has the knowledge or ability to fulfill its claims and whether the firm can be trusted to tell the truth or not" (Newell and Goldsmith, 2001, p. 235). Following Hovland et al. (1953), perceived expertise (the level of competence that made that firm perceived as being able to fulfill its promises and to satisfy customers' needs) and trustworthiness (the extent of perceived honesty, reliability, solidity, sureness of the company and sensitivity to customers' needs) has been seen as essential for corporate credibility. Corporate likeability (seen as the perceived qualities of the company, such as being funny, attractive, and dynamic) could also affect its perceived credibility. In this vein, we could say that corporate credibility measures if customers consider the company good at what it does, devoted to its clients, respectable, and likable.

In the case of sustainable companies, preserving corporate credibility could be a difficult task, because people question especially their sustainable claims and are less willing to make compromises. Also, there is a kind of uncertainty in the adoption of sustainable behaviors on a larger scale. Greenwashing practices contributed to the increasing skepticism and to a real "credibility gap" between what a firm asserts and what it does in terms of sustainability actions (Bae, 2018). If the corporate statements about sustainability are not supported with facts, the credibility of that company will decrease. Even if sustainability represents an asset, the perceptions about corporations could be seriously damaged if the company does not act sustainably (Musgrove, Choi and Chris Cox, 2018). The sustainability reports are studied with maximum interest (Wanner and Janiesch, 2019), cosmetics being an object of public scrutiny for their possible negative effects on the environment.

Female consumers are conceived as more sensitive than male consumers when it comes to ethical issues; they have more unfavorable attitudes than males about companies that behave negatively or have a bad reputation. But when the respective corporation has a good reputation, gender differences do not occur in the perception of a company (Bailey, 2005). Thus, we are interested to examine whether male and female groups score similarly in the perception of corporate credibility for this specific category of sustainable cosmetics companies. Consequently, the following non-directional research question is being formulated:

RQ4: Is there a difference between female and male customers regarding the SCB corporate credibility?

1.5. Intention to join a brand page

A brand page is an online platform which feeds the customers with ad content with every post. At the same time, a consistent body of literature points towards message traits (such as interactivity) and message strategy as the main ways to attract and engage the consumer and develop brand communities. Informational posts, mediated by experiential value, influence the customers at a behavioral level, leading to consistent engagement. The interaction posts directly induce behavior engagement, while image posts do not impact engagement (Gutiérrez-Cillán, Camarero-Izquierdo and San José-Cabezudo, 2017). Media content and type of posts manifest significant effects on online engagement. In this respect, brand managers should carefully prepare strategies for customer online engagement since social networking sites do not constitute a simple alternative nowadays, but a main tool to get people engaged. Bae (2018) insists upon the fact that the perception of corporate credibility meaningfully shapes the intention to join a brand page. Even if the brand page activities have effects on purchase intention, John et al. (2017) found that this relationship is way more complex, the number of likes and comments, even active participation in brand communities, do not automatically translate into purchase intention.

Chow and Shi (2015) used Customer Value Theory and developed a complex model that explains the antecedents of satisfaction with brand page. The authors point out the fact that gender manifests a meaningful effect on Internet usage, but also in terms of positive word of mouth. Ngah et al. (2021) investigated the purchase intention toward cosmetics and studied potential differences between males and females in Muslim millennials. Their findings show that perceived behavioral control seems to influence males in a significant way, while for females the influence comes from subjective norms. Therefore, in this exploratory study, we formulate the following non-directional research question:

RQ5: Is there a difference between female and male customers regarding their intention to join a SCB page?

1.6. Social prestige

According to Maner (2017, p. 526), prestige "is a strategy through which people gain and maintain social rank by displaying valued knowledge and skills and earning respect". Mileva et al. (2016) showed that the use of cosmetics is correlated with social status. Several differences between female and male consumers' perceptions were noticed: women using cosmetics were perceived as attractive by both categories; women using cosmetics were perceived by female subjects as higher in dominance, while male subjects rated them as more prestigious. Cosmetics make women appear more self-confident and competent (Bradshaw and Delpriore, 2021). When women wear cosmetics, they are perceived as being healthier, self-assured, and more likely to have prestigious jobs (Nash, et al., 2006), though early research (Kyle and Mahler, 1996) indicates that cosmetics could have bad consequences on the perception of their competence. Cosmetics are associated with social standing and visibility, and these are important reasons that motivate women toward conspicuous consumption. There are "status motives in purchases of women's cosmetics" (Chao and Schor, 1998, p. 128), not only utilitarian means. Luxury cosmetics emphasize the public display of prestige and status, with men having fewer positive attitudes towards luxury brands and a lower purchase intention than women. For the later, luxury brands offer status, hedonic use, and uniqueness (Stokburger-Sauer and Teichmann, 2013). Thus, we propose the following non-directional research question:

RQ6: In the case of SCB, is there a difference between female and customers regarding social prestige?

1.7. Resilience to negative information

At the company level, resilience and sustainability are two main strategies for long-term development, even if they were usually studied separately (Winnard, et al., 2014). Resilience is a term derived from ecology, signifying the capacity of a system to cope with perturbation and to return to stability. The resilience of companies has three main objectives: reduction of risk, vulnerability, and uncertainty. It also represents a specific ability of a firm to reinvent itself if the context changes. Companies that act resiliently in a strategic way could anticipate different changes and not just respond to variations.

At the consumers' level, resilience to negative information is conceived as an "extra-role behavior" that occurs when identification with a brand is high (Elbedweihy, et al., 2016). The identified consumers will downplay any negative information (Bhattacharya and Sen, 2003) because consumer-company identification leads to trust in the company's ability to fulfill its promises. Consumers are more prone to forgive a company for its mistakes or just to ignore them if they have powerful relationships with it. Stronger attachment leads to consumers' defensive behaviors of the brand (Japutra, Ekinci and Simkin, 2018). At the same time, as Bhattacharya and Sen (2003) asserted, resilience is rather nonlinear: the most committed customers will react very strongly (and most often permanently) to major negative information

related to the brand because of the magnitude of betrayal felt. So, resilience implies a delicate balance between the magnitude of negative information and problems that a certain brand has and the degree of consumer-brand identification.

Resilience to negative information is a consequence of brand attractiveness, while brand loyalty does not have a direct influence on people's resilience to negative information, because not all loyal customers downsize this information about their preferred brand (Elbedweihy, et al., 2016). Resilience to negative information has a positive correlation to purchase intention (Torres and Augusto, 2019), while brand attachment is positively linked to resilience to negative information (Japutra, Ekinci and Simkin, 2018). There is also a relevant impact of brand trust on resilience to negative information (Marzocchi, Morandin and Bergami, 2013). In the case of corporate hypocrisy, consumers had lower levels of trust and consequently, their resilience decreased (Jung, Bhaduri, and Ha-Brookshire, 2020).

Although there is consistent literature that examines the general psychological aspects of resilience, there are no significant results for the field of SCB. This is an important piece of information that is missing from the literature and our study aims to improve the current state of the art. Therefore, the following non-directional research question is being proposed:

RQ7: Is there a difference between female and male customers regarding their resilience to negative information about SCB?

1.8. Purchase intention

Purchase intention indicates "the possibility that consumers will plan or be willing to purchase a certain product or service in the future" (Wu, et al., 2011, p. 32). The measurement is a problematic process; the theory of planned behavior sets two main conditions to correctly predict behavior from the statement of intentions: the behavior must be in the person's full control and the intentions must be measured just prior to the manifestation of that behavior. The readiness to buy is linked more with existing brands than with new ones, also more with durable products than perishable ones; also, purchase intentions are significantly shaped by consumer-brand trust, credibility, and authenticity. Brand-perceived authenticity has an indirect impact on purchase intention, including a premium price, and on the "willingness to forgive mistakes" of the brand (Fritz, Schoenmueller and Bruhn, 2017).

Gender seems to represent a meaningful component of the environmentally oriented consumer, with female consumers more interested in buying green products and displaying more pro-environmental behaviors than male consumers (Pillai, 2013). Other studies found that male consumers intend to buy green cosmetic products more than female consumers and to be more pro-environmentally engaged, with stronger altruistic values (Quoquab, Jaini and Mohammad, 2020). Women are more inclined to purchase natural cosmetics than men (Matić and Puh, 2016) and consumers that are open to new brands will be more likely to buy organic products. Regarding new brands, female respondents also manifest higher purchase intents than males, showing more confidence in unfamiliar brands than males do, a situation explained through instruments derived from evolutionary psychology (Karpinska-Krakowiak, 2021). There are significant other differences between male and female groups at many levels, such as: "amount of money spent on cosmetics each month", "amount of money spent on purchasing cosmetics each time", and "time spent on cosmetics" (Liu, et al., 2013). Gender differentiations were perceived in hedonic orientation for female customers versus utilitarian orientation for male clients (Borges, Babin and Spielmann, 2013). Considering these studies from the literature, we propose the following non-directional research question:

RQ8: Is there a difference between female and male customers regarding their purchase intention of SCB?

2. Data and research methodology

A quantitative approach based on a self-administered online survey was employed among Romanian consumers during March – April 2021. The invitation to participate in the study was sent using social media platforms. We used a non-probability sampling technique, namely snowball sampling because the participants needed to be customers of sustainable cosmetics brands. The online questionnaire contained scales adapted from the literature to suit the cultural, economic, and social context of Romanian consumers of SCB. The instrument was divided into two sections. The first section contained a filter question used to ensure the relevant data for analysis and a set of items used to collect demographic data. The second section of the online questionnaire consisted of 8 scales adapted from the literature that were used to measure the research variables.

Specifically, we used the brand attachment scale adapted from Park et al. (2010), the brand authenticity scale developed by Schallehn, Burmann and Riley (2014), the brand trust scale from Koschate-Fischer and Gartner (2015), the intention to join brand page and corporate credibility scales proposed by Bae (2018), social prestige instrument developed by Hwang et al. (2021), purchase intention scale adapted from Putrevu and Lord (1994) and resilience to negative information scale developed by Elbedweihy et al. (2016). Most subjects spent between 10 and 15 minutes filling out the entire questionnaire. Priori, a pilot study was conducted on a sample of 200 respondents to ensure that the translation of the items from English into Romanian was adequate and to diagnose other formal and content-related errors to improve the instrument.

3. Results

3.1. Sample characteristics

We collected data from both females and males customers from Romania, an important EU market for SCB. Because we were interested to compare female and male customers of SCB, the 50%-50% ratio in our convenience sample was a precondition. The respondents were prevalent young people aged between 16 and 27 (81.2%). They were mainly students and employees (in enterprises), accounting for 60.76% of the total sample. Individuals' income per month was less than RON 3003 (i.e., RON 3003 ≈ 721 USD) for 77.8% of participants. The sample characteristics are shown in Table 1.

Table 1. Demographic characteristics of the survey participants

Variables		Frequency	Percentage
Sex	Male	144	50%
	Female	144	50%
Income/month (RON)	≤1000	107	37.2%
	1001-2001	57	19.8%
	2002-3002	60	20.8%
	3003-4003	28	9.7%
	4004-5004	18	6.3%
	5005-6005	7	2.4%
	>6005	11	3.8%
Age	16-21	115	40.1%
	22-27	118	41.1%
	28-33	23	8%
	34-39	11	3.8%
	40-45	8	2.8%
	46-51	10	3.5%
	>51	3	0.7%

Variables		Frequency	Percentage
Occupation	Student	125	43.4%
	Pupil	12	4.17%
	Staff in a public institution	18	6.25%
	Individual business	14	4.86%
	Liberal professions	26	9.03%
	Employee in enterprise	50	17.36%
	Unemployed	6	2.08%
	Other	37	12.85%

Source: Own development

3.2. Reliability Analysis

The data obtained from the online questionnaire were first organized using Microsoft Excel. All responses were coded to summarize the data. Afterward, we imported the data into SPSS 22.0 software and assigned each variable a specific code. A total of 288 valid responses were collected from both males and females. Participants answered the online questionnaire items by referring to the sustainable cosmetics brand that came first in their mind and rated their level of agreement for each item, on a 7-point Likert scale (1—Strongly disagree, 2—Disagree, 3—Somewhat disagree, 4—Neither agree nor disagree, 5—Somewhat agree, 6—Agree, 7—Strongly agree).

The reliability test was used and the Cronbach's alpha (α) coefficient was calculated for each variable. Even though there is no universally accepted minimum standard for Cronbach's alpha (α) coefficient, in the literature, the reference values are typically interpreted as follows: values around .90 are considered excellent; around .80, very good; and around .70, sufficient (Kline, 2005). The results are shown in Table 2. The reliability of each scale was greater than 0.7, indicating that they were sufficient and good; therefore, the data could be used for further analysis.

3.3. Group comparison between male customers and female customers of SCB

To run a group comparison between male customers and female customers of SCB, first we analyzed the normality of the data distribution with the Kolmogorov-Smirnov and Shapiro-Wilk tests. The results showed that the data was not normally distributed for the research variables (Sig. <.05). In Table 3 we report the results of descriptive statistics and normality tests for each variable.

Table 2. Scales and items

Measured Variables & Items	Mean	Standard deviation	Cronbach alpha
Brand Attachment			
1. The SCB X is part of me and who I am.	4.30	1.56	0.875
2. I feel personally connected to the SCB X.	4.59	1.46	
3. My thoughts and feelings toward the SCB X often automatic, coming to mind seemingly on their own.	4.41	1.54	
4. My thoughts and feelings toward the SCB X often automatically come to your mind naturally and instantly.	4.48	1.54	

Measured Variables & Items	Mean	Standard deviation	Cronbach alpha
Brand Authenticity			
1. The SCB X possesses a clear philosophy which guides the brand promise.	5.16	1.21	0.818
2. The SCB X knows exactly what it stands for and does not promise anything which contradicts its essence and character.	5.24	1.15	
3. Considering its brand promise, the SCB X does not pretend to be someone else.	5.41	1.13	
4. Considering its brand promise, the SCB X doesn't curry favor with its target group; moreover, it shows self-esteem.	5.32	1.25	
5. The SCB X distorts itself, to match the contemporary market.	5.54	1.11	
Brand Trust			
1. I am confident in the SCB X's ability to perform well.	5.50	1.12	0.853
2. I trust the SCB X.	5.57	1.13	
3. I rely on the SCB X.	5.46	1.15	
4. The SCB X is safe.	5.55	1.10	
5. I expect the SCB X to deliver on its promise.	5,65	1.17	
Corporate Credibility			
1. The company of the SCB X has a great amount of experience.	5.74	1.15	0.851
2. The company of the SCB X is skilled in what they do.	5.65	1.07	
3. The company of the SCB X has great expertise.	5.53	1.11	
4. I trust the company of the SCB X.	5.49	1.15	
5. The company of the SCB X is honest.	5.20	1.18	
Intention to Join a Brand Page			
1. It is extremely likely for me to join the SCB X page.	4.87	1.72	0.911
2. It is possible that I will join the SCB X page.	5.04	1.66	
3. It is extremely probable that I will join the SCB X page.	4.87	1.81	
Social Prestige			
1. The SCB X signifies my trendy image.	4.43	1.57	0.871
2. The SCB X represents the latest lifestyles.	4.67	1.34	
3. The SCB X symbolizes my social image.	4.13	1.62	
4. The SCB X is associated with the symbol of prestige.	4.75	1.39	
5. The SCB X tells something about one's social status.	4.06	1.70	
6. The SCB X is associated with wealth.	4.05	1.63	
Purchase Intention			
1. It is very likely that I will buy the SCB X.	5.66	1.27	0.817
2. I will purchase the SCB X the next time I need this type of product.	5.60	1.15	
3. I will definitely try the SCB X.	5.76	1.12	

Measured Variables & Items	Mean	Standard deviation	Cronbach alpha
Resilience to Negative Information			
1. If the SCB X did something I didn't like, I would be willing to give it another chance.	4.12	1.61	0.750
2. I will disregard any negative information that I hear or read about the SCB X	3.70	1.62	
3. I will forgive the SCB X when it makes mistakes.	4.74	1.34	

Source: Own development

Therefore, a Mann-Whitney U test was used to assess group comparison between male customers and female customers of sustainable cosmetics brands. The nonparametric Mann-Whitney U test was carried out because we needed to evaluate if female and male customers of SCB significantly differ regarding their: (1) brand attachment, (2) brand authenticity, (3) brand trust, (4) corporate credibility, (5) intention to join a brand page, (6) social prestige, (7) resilience to negative information, (8) purchase intention.

Table 3. Descriptive statistics and the normality tests results

Variable	Mean	Std. Dev.	Min.	Max.	Kolmogorov-Smirnov			Shapiro-Wilk		
					Stat.	Df.	Sig.	Stat.	Df.	Sig.
Brand Attachment	17.77	5.21	4.00	28.00	.099	288	.000	.981	288	.001
Brand Authenticity	26.66	4.47	12.00	35.00	.067	288	.003	.982	288	.001
Brand Trust	27.72	4.51	11.00	35.00	.098	288	.000	.968	288	.000
Corporate Credibility	27.61	4.49	10.00	35.00	.111	288	.000	.969	288	.000
Intention to Join Brand Page	14.78	4.79	3.00	21.00	.119	288	.000	.939	288	.000
Social Prestige	26.07	7.26	8.00	42.00	.082	288	.000	.986	288	.008
Purchase Intention	17.02	3.03	4.00	21.00	.133	288	.000	.938	288	.000
Resilience to Negative Information	12.55	3.75	3.00	21.00	.094	288	.000	.986	288	.008

Note: The null hypothesis states that data is normally distributed and is accepted if $p > .05$. The alternative hypothesis is accepted (i.e., data is not normally distributed) if $p < .05$.

Source: Own development

To answer our research questions, the following hypothesis were formulated to be tested:

H_1: There is a significant difference regarding *brand attachment of SCB* between females and males.

H_2: There is a significant difference regarding *brand authenticity of SCB* between females and males.

H_3: There is a significant difference regarding *brand trust of SCB* between females and males.

H_4: There is a significant difference regarding *corporate credibility of SCB* between females and males.

H_5: There is a significant difference regarding *intention to join a SCB page* between females and males.

H_6: There is a significant difference regarding *the social prestige in the case of SCB* between females and males.

H_7: There is a significant difference regarding *the resilience to negative information about SCB* between females and males.

H_8: There is a significant difference regarding *the purchase intention of SCB* between females and males.

First, we ensured that the four assumptions to run this nonparametric test were met: (1) the dependent variables were measured at the continuous or ordinal level (i.e., the research variables were measured using ordinal scales), (2) the independent groups consist in a dichotomous variable (i.e., sex), (3) the observations were independent (i.e., we had different participants in each group), and (4) the distribution of scores for both groups have the same shape (Fay and Proschan, 2010).

To assess if the variables have de same distribution shape, we used the Levene's Statistic Test of Homogeneity of Variance (Levene, 1960). Levene's test for equality of variances was found to be violated for *brand trust* ($p = .001$, $p < .05$), *corporate credibility* ($p = .002$, $p < .05$) and *purchase intention* variables ($p = .048$, $p < .05$) needed for the Mann-Whitney U test. The results are depicted in Table 4.

Table 4. Results of Levene's statistic test of homogeneity of variance

Variables	Levene Statistic Based on Median and with adjusted df.	Df. 1	Df. 2	Sig.
Brand Attachment	1.129	1	284.100	.289
Brand Authenticity	2.546	1	285.683	.112
Brand Trust	10.872	1	281.480	.001
Corporate Credibility	9.944	1	278.962	.002
Intention to Join Brand Page	0.262	1	284.024	.609
Social Prestige	0.163	1	278.725	.687
Purchase Intention	3.954	1	285.831	.048
Resilience to Negative Information	0.539	1	277.783	.463

Note: The null hypothesis of equal variances (i.e., the variances are not equal) is rejected if $p < .05$. The alternative hypothesis is accepted (i.e., the variances are equal) if $p > .05$.

Source: Own development

By visually inspecting the shapes of the distributions using the population pyramid histogram we also concluded that *brand trust, corporate credibility,* and *purchase intention* variables distributions are not similarly shaped. Therefore, because the male and females' groups had differently shaped distributions of *brand trust*, *corporate credibility,* and *purchase intention* (i.e., the dependent variable), we could not make inferences about differences in medians between groups, but we could investigate the differences in distributions, lower/higher scores and/or mean ranks.

For *brand attachment, brand authenticity, intention to join brand page, social prestige,* and *resilience to negative information* the distributions were similarly shaped.
In the analysis, the following U statistics were used:

$$U_i = n_1 n_2 + \frac{n_i(n_i + 1)}{2} - \sum R_i,$$

where U_i is the test statistic for the sample, n_i represents the number of values from the sample, n_1 is the number of values from the first sample, n_2 is the number of values from the second sample, and $\sum R_i$ is the sum of the ranks from the sample (Corder and Foreman, 2009). In Table 5 we present the results of the results of Mann–Whitney U test.

Table 5. Results of Mann–Whitney U test

Group	n	Variable	Mdn.	*U*	*z*	P-Value	*r*	Hypotheses
Male	144	Brand attachment to SCB	17	9191.000	-1.669	.095	.139	H_1 - Unsupported
Female	144		19					
Male	144	Brand authenticity of SCB	26	7890.000	-3.515	.000***	.207	H_2 -Supported
Female	144		28					
Male	144	Intention to join brand page of SCB	14	7242.000	-4,440	.000***	.261	H_3 -Supported
Female	144		16					
Male	144	Social prestige of SCB	27	9574.500	-1.125	.261	.066	H_4 - Unsupported
Female	144		25					
Male	144	Resilience to negative information about SCB	13	9606.000	-1.083	.279	.063	H_5 - Unsupported
Female	144		12					

Note 1: * $p > .05$; ** $p > .01$; **0 $p > .001$.

Note 2: We computed the effect size using the formula: r = Z /√N, where Z is Z Statistics and N is the number of cases. According to Cohen (1992), r value can be interpreted as follows: = .1 the effect size is small, .3 = the effect size is medium, and .5 the effect size is large.

Source: Own development

4. Discussion

First, we found that male and female customers differ substantially when it comes to the variables of brand authenticity and intention to join a brand page in the domain of SCB.

The results of this study indicate that male and female customers differ substantially when it comes to SCB authenticity, meaning that female customers show a greater appreciation for brand authenticity than males. In this case, the effect size was small (r = .207) and statistically significant (p = .000). This signifies that female clients look more than their male counterparts towards sincere, and genuine SCB. Existing literature offers a possible explanation for this result, indicating that female consumers show greater appreciation for brand authenticity than male customers because they search for relational authenticity with the brands (Ilicic and Webster, 2014) and perceive some qualities of the products as an indication of the brand trying to meet special demands and being natural, serious, and reliable (Bruhn, et al., 2012).

Also, our analysis indicates a significant (p = .000) small difference between males and females regarding their intention to join a SCB SNS page (r = .261). This result correlates with Muscanell and Guadagno (2012) studies that reported that females use SNSs for relationship maintenance and with Huaman-Ramirez and Merunka's (2019) work who confirmed in their study that female customers tend to be more socially oriented than males; in our case, female

consumers want to preserve their connection with the SCB. Moreover, this supports the idea that female customers need constant information about this category of brands, and they are more inclined to engage in brand communities.

We also found insignificant differences between male and female customers when we tested brand attachment (p = .095), social prestige (p = .261), and resilience to negative information (p = .279). These results could be explained by Geoffrey Jones's work (2010) which asserts that we are witnessing now a return to pre-19th century use of cosmetic products when there were virtually no gender differences. This powerful divide between genders is a trait of the last two centuries (Jones, 2010). This is also seen in the growing number of cosmetic products that target men. Moreover, female and male customers might display similar levels of interest in terms of social status or conspicuous consumption.

Conclusions

This study performed an empirical analysis concerning sustainable cosmetics brands. Our exploratory investigation focused on assessing the presence of significant differences between male and female consumers regarding the perception of SCB. After we reviewed the literature, we found that it lacked relevant cues concerning brand authenticity and resilience to negative information when it comes to female and male differences in the SCB sector. In this respect, our study tried to contribute, at least partially, to fill this knowledge gap. Also, we found insignificant differences between male and female customers regarding brand attachment to SCB, social prestige of SCB, and resilience to negative information about SCB.

From a practical point of view, our study produced a few meaningful results. Brand managers and advertisers should consider male and female customers when they develop their brand communication strategies (e.g., advertising campaigns). For instance, different cues should be used for engaging males on the respective brand pages. On the other hand, the companies should take necessary measures and adopt policies that translate into the brand being perceived as sincere and authentic by female customers. Moreover, SCB should not disappoint female customers as they perceive the relationship with the brand as a dual one (Monga, 2002). Cosmetics brand managers should also mind the fact that, in time, the concept of brand authenticity enlarges, as pointed out by Visconti (2010). Thus, naturalness, originality, exceptionality, and referentiality (rather traditional ingredients of authenticity in the world of cosmetics) should now be joined by influential, understood as the capacity of cosmetic brands to be sustainable and to develop relative subsequent brand narratives. Brand managers should also avoid greenwashing and unsubstantiated sustainable claims at any cost. Moreover, it is essential for companies to soldier on when it comes to fulfilling promises and finding ways to be dynamic and responsible socially, economically, and environmentally.

This study has also inherent limits. First, there is the limitation of generalization of results since our study focused on Romanian customers of SCB and used a snowball sample. Therefore, future research could enlarge and diversify the sample to get more in-depth findings. Second, in our research, the majority of respondents were aged between 16 and 27 years old. Future studies could cover other age cohorts to both extend the results and run comparative analyses. Third, the research could be extended by including respondents with significant differences in cultural background in terms of cosmetic use and sustainable knowledge and behaviors. Also, the results of this exploratory study must be considered in a SCB context. Finally, future studies could test more complex models, based on our exploratory research.

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THE EFFECT OF DELAY IN CONSTRUCTION PROJECTS TIMETABLES ON THE BUILDING OF SMART CITIES

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Abstract: Smart cities leverage technology and data in order to improve the quality of life of their residents, the effectiveness and sustainability of municipal systems, and economic development. These cities offer varied technologies, such as sensors and data analysis for the purpose of collecting and analyzing data in real-time. Thus, they facilitate a rapid and efficient decision-making. Improvement of the quality of life is achieved by providing efficient transportation, clean energy, and high-quality public services, such as healthcare and education. Furthermore, smart cities enhance their sustainability by reducing the consumption of resources and emission of greenhouse gases, promoting their renewable energy, as well as creating durable infrastructures that can withstand natural disasters. Delays in the construction timetables considerably affect the development and implementation of smart cities. Various factors can account for such delays. For example: unexpected site conditions, disruptions caused by the weather, changes of design or scope of work, as well as lack of materials or manpower. Smart cities involve complex and connected systems, such as transportation, energy, and communication networks and, thus, delays in the timetables can compromise their timing and continuity. These factors entail increased costs and potential failures of the project. The delay in building a smart transportation network affects the branching out of the systems, the traffic management, or smart parking. Project managers should adopt proactive measures, e.g., risk management and contingency plans, as well as perform current monitoring and reporting in order to moderate the impact of timetable delays on the construction of smart cities.

Keywords: timetable delays; project management; smart cities; changing reality; construction industry

JEL classification: R58

Introduction

The building of smart cities involves improvement of the residents' quality of life, by providing them with efficient transportation, clean energy, and high-quality public services, such as healthcare and education. Moreover, these cities strive to enhance sustainability by reducing the consumption of resources and hothouse gases emission, promotion of renewable energy, and creation of infrastructures that can withstand natural disasters.

Construction timetable delays can crucially affect the development and implementation of smart cities. These delays might be due to various reasons, such as: unexpected site conditions, weather-oriented problems, changes in the design or scope of the work, as well as lack of materials or workers. Smart city projects frequently comprise complex and interconnected

systems, e.g., transportation, energy, and communication networks. Delays in construction might disrupt the timing and sequence of these systems, leading to increased costs and potential failures in the project. For example, if the construction of a smart transportation network is delayed, this can impact the spreading out of other systems, e.g., management of smart transportation or parking.

Project managers should adopt proactive measures, e.g., risk management, contingency plans, as well as current follow-up and reporting, aiming to mediate the effect of these timetable delays in the construction of smart cities. Risk management involves identification of potential risks and development of strategies for reducing them before they occur. Contingency plans consist of the development of alternative plans in case of unexpected delays or disruptions. Constant follow-up and reporting assist in the early identification of potential delays and in taking remedial measures for minimizing their effect. In addition to these measures, stakeholders of smart city projects should prioritize cooperation and communication. This implies the participation of all parties involved in the project - contractors, suppliers, designers, and government agencies – in regular discussions for the purpose of identifying and resolving potential problems as quickly as possible. Construction timetable delays can considerably affect the success of smart city projects by adopting proactive measures and prioritizing collaboration and communication. Stakeholders can minimize the impact of delays and guarantee the timely completion of projects.

Construction projects constitute an essential part of the global economy, since they provide the infrastructure and buildings required for supporting the growth and development of communities around the globe. From small-scale renovations and up to large-scale developments, construction projects can vary in size and complexity.

Smart cities use a diversity of technologies and applications in order to accomplish the following goals:

1. Smart transportation systems, including: smart traffic management systems, real-time information about public transportation, and autonomous vehicles.
2. Smart energy systems, including: use of renewable energy sources, smart networks, and energy-saving buildings.
3. Smart public services, including: smart waste management, public safety systems, and online governmental services.
4. Smart buildings, including: smart buildings management systems, energy-saving systems, and sensors that optimize the use of space.
5. Smart citizens' involvement, including: platforms that enable residents to participate in decision-making processes, provide feedback, and access services and activities in the city.

To sum up, smart cities are designed to use technology and data in order to improve the quality of life, sustainability, and economic development of urban areas, while enhancing the efficiency of municipal systems.

Smart city projects often involve complex and interconnected systems, such as transportation, energy, and communication networks. Construction delays can disrupt the timing and sequencing of these systems, leading to increased costs and potential project failures. For example, if the construction of an intelligent transportation network is delayed, it may affect the deployment of other systems, such as traffic management or smart parking.

Project managers need to adopt proactive measures, e.g., risk management, contingency planning, and regular monitoring and reporting to mitigate the impact of construction timetable delays in smart cities. Risk management involves identifying potential risks and developing strategies for reducing them before they occur. Contingency planning consists of developing alternative plans in case of unforeseen delays or disruptions - regular monitoring and reporting

help in the identification of potential delays early, taking corrective measures for minimizing their effect.

Effective project management constitutes an essential factor in driving the success of industry-oriented projects, such as construction. The ability of the project managers to stick to timetables, remain within budget, and ensure project quality, all serve as indicators of a project's success (Işik, et al., 2009). The PMBOK® (Project Management Body of Knowledge) Guide was produced by The Project Management Institute (PMI) to provide outlines for the approaches and processes, tools, and needs for successful project management (PMI, 2021).

Many studies of project management have been conducted, as well as relevant research of project management and project management success (El-Razek, et al., 2008). However, little research has investigated the success of construction projects conducted according to the Waterfall model that has incorporated frequent changes. Since the 1990s, with the development of the online platform, the disadvantages of using the Waterfall model in construction projects has begun outweighing its advantages. The Internet facilitated daily updates, with processes such as software updates, user reviews, and troubleshooting requirements being received in real-time. The updated requirements and considerations generated frequent changes in the project, even during the execution phase. Hence, since the Waterfall model relied on complete characterization at the start of the project, any change request was likely to be costly and cumbersome.

This study focuses on managing construction projects in a changing reality and changing management during the planning or execution stages, most likely in the building Smart Cities.

1. Literature review

Nowadays, construction projects constitute a major contributor to the global economy, with the construction industry accounting for a considerable share of GDP in many countries. Construction projects can be found in virtually every corner of the world. They often collaborate with various professionals, including architects, engineers, contractors, and project managers. Nevertheless, construction projects can also be challenging, often subject to various risks and uncertainties, among them regulation changes, unpredictable weather, and unexpected site conditions. Managing these risks and ensuring that projects are completed on time and within budget, requires careful planning and coordination.

Despite these challenges, construction projects are a key driver of economic growth and development worldwide. As the world's population and urbanization rates continue increasing, the demand for new buildings and infrastructure remains high. This presents both opportunities and challenges for the construction, requiring the development of new technologies and approaches for supplying the growing demand for construction projects sustainably and efficiently.

Construction projects are executed in complex dynamic environments and changing reality, often characterized by uncertainty and risk. The literature presents ample evidence that many construction projects fail to accomplish their time, budget, and quality goals (Al-Bahar and Crandall, 1990; Assaf and Al-Hejji, 2006; Mulholland and Christian, 1999). Ineffective planning and scheduling have been acknowledged as meaningful causes of project delay. Mulholland and Christian (1999), as well as Assaf and Al-Hejji (2006) argued that inferior planning was the third major cause of company bankruptcies in the Belgian construction industry. Wei (2010) found that the most effective ways of reducing construction delays and staying within the scheduled time frameworks were exercising strict oversight and management, ensuring strategic planning, and maintaining clear and open communication channels.

Project Managers in the construction field are supposed to lead the respective projects in their lifecycles. Construction projects involve many risks and are unpredictable. It is not an easy task to manage them as a manager. According to Turner (2014), construction projects need flexible leadership and management to respond to changes during their execution. To minimize the impact of changing circumstances on a construction project, the project team should have a flexible plan and be prepared to adapt to changes as they arise. Managers have used conventional project management methods, such as Waterfall, for dealing with construction project management challenges. However, due to weaknesses associated with conventional approaches to project management, the agile project management technique was designed for use in the construction industry (Turner, 2014). Nonetheless, its use has caused several obstacles. It is necessary to understand these challenges to improve their use in the future, for the purpose of enhancing the process of construction project management.

Only a limited number of studies have explored obstacles associated with the agile methodology in construction and design projects. Hence, many managers find it challenging to use this methodology in such projects. This study aims to address this problem by looking in-depth at the challenges of using agile methodology in construction projects, as well as the way these challenges may be resolved in the future. While construction projects are undertaken daily worldwide, each project is unique because of aspects that are specific to the construction site and the construction activity circumstances. Construction necessitates coordination between the people involved and the materials needed, and depends on material supplies, available labor, and the conditions at the construction site. Other unpredictable factors, such as last-minute changes or unreliable suppliers, may also lead to difficulties in ensuring that construction projects are completed on time (Viles, et al., 2019).

Delay is one of the most common issues reoccurring in the construction industry, resulting in negative impacts on the projects' success in terms of time, cost, quality, and safety (Pourrostam and Ismail, 2012). Timetable delays may have critical financial implications for the project sponsors and substantial social costs to the public, justifying research focused on timetable delays (Padalkar and Gopinath, 2016). Although some research of timetable delays has been conducted worldwide over the last two decades, studies of this phenomenon in Israel have been limited (Rozenfeld and Yokle, 2011). Furthermore, little research has focused on the success of construction projects using the Waterfall model, which incorporates frequent changes during planning and execution. Although extensive efforts are exerted, aiming to improve construction project controls in the US and the UK, a slight improvement in project performance associated with timetables has been noted. This study examines timetable delays in construction projects, suggesting a practical instrument for managing the timetable in construction projects while adapting to the changes that transpire during the project.

The existing literature has not successfully managed to address the problem of obstacles associated with the use of the agile methodology in the management of construction projects. Most of the studies have focused mainly on the benefits of using agile methods and success factors associated with its application in project management (Cohn and Fredrickson, 2010). Consequently, it is necessary to conduct comprehensive research that focuses basically on the challenges associated with the use of construction project management.

The agile methodology in the management of construction projects involves considerable obstacles that result in the collapse or inefficiency of using the available resources. Thus, the application of the agile methodology in construction projects faces tremendous barriers in enhancing its ability to ensure that effective project management. Moreover, it reduces the chances of project timetable delays or the use of substantial financial, human, and technical resources that would have otherwise been reduced. Solving this research problem experienced in construction project management. Will in future render effective the management of projects that use the agile methodology.

In the past years, implementing the agile methodology has become prevalent in construction companies (Thesing, et al., 2021). However, quick changes primarily relate to the Information Technology industry. To better understand what is involved in such transformation, the main issues of "Feasibility in Applying Agile Project Management Methodologies to Building Design and Construction Industry" will be reviewed with respect of Agile adoption.

Different issues can arise while transforming conventional project management into agile processes. As it requires a meaningful fundamental cultural change in a company, it is essential to chart in advance the issues that can inhibit the generation of such a change. Understanding potential issues facilitates the outline of the proper measures that can be charted and pinpointed to assure the success of such reforms. The main focus ultimately is figuring out how to adopt the Agile project management structure in the building design and construction projects, the methodology and process. Several studies that have investigated the Agile method versus the Waterfall method have been conducted, yet they are not explicitly related to the construction industry. This study aims to create a technique and a modular process so that construction and infrastructure project managers can identify and manage changes during the project.

According to Dybå et al. (2014), the existing literature on agile methodology only focuses on its positive aspects of project management. Hence, little attention has been paid to its weaknesses when applied to the management of projects, such as construction projects. The gap in the existing literature resides in the fact that there is no adequate information concerning the way of overcoming the current obstacles in agile construction projects (Vijayasarathy and Turk, 2008). Thus, there is a need for research that aims to bridge this gap in the literature dealing with the agile methodology in construction projects.

2. Data and Research Methodology

This study aims to point out the critical root causes of deviations from timetables of construction and infrastructure projects, following changes in the characterization of requirements during the planning and execution stages. The study focuses on an in-depth investigation of the phenomenon in a changing reality. The original timetable (as planned) is known, and the actual program (as-built) is known. What is unknown is the changes that occur during the project external and internal impacts that will affect the original or planned timetable. These root causes may indicate the source of the problem in order to cope with the root causes rather than coping only with the symptoms. This study proposed a causal model, based on the synthesis of the Agile models and empirical studies that have been conducted in the field of construction project delays. Unplanned changes in construction projects are common and lead to disruptive effects, such as project delays, cost overruns, and quality deviations. Reprocessing due to unexpected changes can cost 10-15 percent of the project value (Senaratne and Sexton, 2009). This study facilitates drawing the developers and project managers' attention to factors that have the most crucial impact on timetable deviations. Given the small number of publications on this topic, the findings of this study can also have implications from the international aspect. The publication of the results can enhance the comprehension of this phenomenon and its reduction. Moreover, the results can draw the attention of public construction clients, developers, project managers, planners, and contractors to the root causes, decreasing the extent of budget deviations in construction. The findings will also suggest a tool for minimizing this disrupting effect by managing these changes more effectively. The results will allow designing a new model for project management. This model integrates the techniques and flexibility of the Agile methodology with the spatial and comprehensive vision of the Waterfall model while meeting fast and changing timetables in construction and infrastructure projects.

This study focuses on managing construction projects in changing reality, defining the success or failure of the project, examining different, new, or conventional methodologies that affect

project success, and building an intermediate method suitable for construction project management. It offers a different point of view on project management, namely project managers experience the integration of several methodologies for accomplishing the project goals. This examination raises difficulties in project management, i.e., project managers do not act by conventional management principles. Instead, they implement the Agile methodologies prevalent in various disciplines of project management, requiring business vision and strategic understanding beyond the managers' professional and technological capabilities.

The life cycle of a construction project consists of various phases and may require the generation of numerous information models (see Figure 1. The participants in the construction project are active during different stages of the project according to their skills. Delays may occur at any phase of the project, and this study will investigate the ways of preventing timetable deviations that affect many construction projects. Most of the construction projects are managed according to the conventional Waterfall Model (see Figure 1).

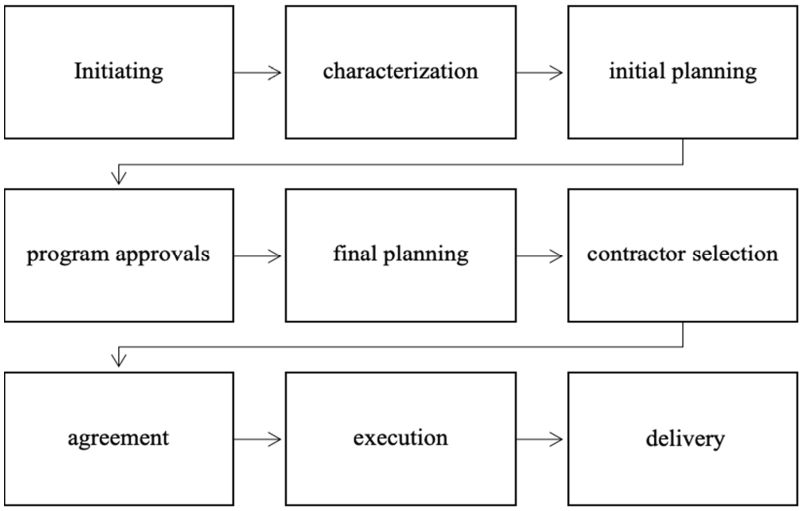

Figure 1: Construction project's process

Source: the author's diagram

This study examines the use of the Waterfall model in construction project management, as well as explores the number of deviations in the construction project timetables and their effect on the project's success. Moreover, it investigates compliance with the plans of a construction project using the Waterfall model when changes in the characteristics of the project are introduced during the planning and execution stages. The Waterfall model takes its name from its resemblance to the way a waterfall flows along with a series of cascades. The project phases are serial, and the model strongly emphasizes the characterization of all the project requirements as a preliminary step in the project planning. One of the main challenges that arise from the use of the Waterfall model is difficulties in making design and requirement changes from the initial plans without incurring additional costs and experiencing timetable deviations. The mixed methods approach integrates quantitative and qualitative research in the research design, as shown in Table 1.

Table 1. Research Design

Research Design	Research Aim	Research Instrument	Research Participants/ Source	Data Analysis Method
Qualitative & Quantitative	To identify the causes of delays in construction projects, examine the use of the Waterfall model in construction project management, and explore the number of deviations in the construction project timetables and their effect on the project's success.	Documentary research of reports	Construction project records from 20-30 projects	Content analysis Frequency analysis
		Closed-ended structured questionnaire	Construction project managers	Correlations, regressions, structural equation modeling
Qualitative	To present guidelines for meeting timetables of construction projects	Interviews & focus group discussion	15 construction practitioners	Content analysis

Source: Author's representation

Data collection from the field will yield qualitative data relating to deviations from construction project timetables. Outcome analysis of the construction project reports will be performed to obtain a preliminary estimate of the scope of construction project delays, and frequency analysis will support an initial analysis of the characteristics of the delays and their effect on timetable deviations.

3. Results and Discussion

Document analysis - sampling about 26 projects, the construction of which has been completed, to obtain a preliminary estimate of the phenomenon scope and an initial analysis of its characteristics.

The document will collect data from different companies and projects.

This document includes summary meetings, BOD reports, finance influences, and critical objects from the projects.

The results were analyzed by structural equation model content:

- Investigating the main causes for delay in a construction project – including those from literature review and actual projects (26 protocols and summaries from Israel) that are repeated in every project and recent research. Analyzing the projects, including delays from the original schedule, budget exceptions, the number of changes during the project, and the reasons for the difference.
- Characterizing the common categories for delays in the construction project schedule.

Table 2. Perceptions of timetable delays in construction's projects: What factors will or will not cause a timetable delay in construction projects?

No.	Executing Corporation	Project Description	Protocol Date	Protocol Type	Category
1	Contractor	Raw Material Warehouse Maytronics Constructing a 4000 m^2 warehouse	16.03.2020	Contractors' meeting on site concerning construction and budget deviations due to a problem on site – a crack between a new and an old building	Unexpected construction problem
2	Construction public company	Hod Hasharon Municipality Development Project	29.12.2021	Budget deviations due to content added throughout the course of the project	Changes during the project
3	Engineering – Contractor	Offices; 10,000 m^2	27.10.2022	The 20-day delay in foundation completion	Equipment supply
4	Engineering – Contractor			Timetable delays due to late supply of an elevator ordered from Switzerland	Equipment supply
5	Engineering – Contractor			Receiving a construction permit may delay settling, as may firefighting permit	Regulation
6	Engineering – Contractor			20 workers shortage on Site	Shortage of workers on site
7	Engineering – Contractor		03.11.2022	Rise of raw materials costs due to market recession; flattening of central wooden core	Raw materials Supply
8	Contractor	Raw Material Warehouse Building 6, 2500 m^2	10.06.2020	Delay in installing rods within the floor due to inappropriate and incompatible work on site	Changes throughout execution
9	Shelfs company	Raw Materials Warehouse Building 5	09.06.2020	Timetable depends upon date of completion and submission of shelving rods	Raw materials Supply
10	Contractor	Electricity Production Hall	09.03.20	Tour with committee's superintendent delays beginning of work	Local government regulation

No.	Executing Corporation	Project Description	Protocol Date	Protocol Type	Category
11	Contractor	Electricity Plant Building 4	09.06.2020	Work stopped due to negligence related to work at height	Work safety
12		Offices building, warehouse building, electricity plant	15.03.2020	COVID-19 restricting arrival of workers to the site and contractors' entering the plant; quarantines.	Shortage of workers on site
13	Contractor	Raw Material Warehouse	07.02.2020	Discovering a pipeline underneath the building following foundations excavation; transferring pipeline and performing a constructive change in the building	Changes throughout execution due to an unplanned proceeding
14	Israel Electricity Corporation	Laying a High-voltage line	04.05.2020	Laying a high-voltage line	Regulation, Israel Electricity Corporation
15	Contractor Engineering	Offices Building	04.06.2020	On 1st June and on Monday, following two days of pole drilling and based upon the surveyor's poles' location scanning on the site, it was found that at that point, the eastern pole's distance (80 95 cm) from the B axis poles is not equal. Thus, it was impossible to put up the eastern posts according correspondence to the plan. Consequently, the final outcome would have been a narrower building	Changes throughout execution; measurement error, construction change
16	Supplier	Shelving Raw Materials warehouse	11.06.2020	Delayed arrival of rods from the Czech Republic, delayed installment of rods	Delay in raw materials supply
17	Contractor	Electronics Plant Building 4	03.06.2020	A seven-month delay in the supply of elevators	Material supply delay; Products for Site

No.	Executing Corporation	Project Description	Protocol Date	Protocol Type	Category
18		Office Building	17.03.2020	Freezing of labor due to COVID-19 related instructions concerning avoidance of over ten workers' gathering	COVID-19
19	Construction public company	Urban Renewal Agreement	19.05.2020	Delay resulting from delayed receipt of permit	Regulation; local Committee
20	Construction public company	Residence Quarter Construction		District committee's approval and urban building scheme certificate	Regulation; district committee, Israel Land Administration
21	Entrepreneur company	Residence Project in Bat Yam		Ramot Shavey Zion signed three agreements with third parties for purchasing segments of a plot of land in southwest Bat Yam bloc 502, plots 115-116 held in partnership by a multitude of owners (Hereinafter: "The Plot of Land")	Legal issues involving the landowners
22	Contractor Engineering	4900 m^2 Mivneh Technologies	07.11.2020	Planning-related Changes	Changes throughout execution
23	Israel Electricity Corporation	Laying a high voltage line	20.04.2020		Planning related changes with further planning alternatives; Dependence upon statutory parties; IEC
24	Contractor	Electronics Plant	04.06.2020	Further Maytronics request for enhancing hall's degree of lighting in building 4 to 750 lux, we examined the various pertaining issues; Planning update requires the following items;	Changes throughout execution – ordering party

No.	Executing Corporation	Project Description	Protocol Date	Protocol Type	Category
25	Contractor	Raw Materials Warehouse	02.04.2020	Information systems and infrastructure preparedness	Preparedness of intra-organizational interfaces – a recurrent problem
26	Energy company Public	Solar panel construction	2019	Energy's Periodical Report	Delay in raw Materials supply

Source: Companies website, projects protocols, https://maya.tase.co.il/

To sum up, a delay in project timetables is affected by various factors rather than by one element. The factors do not necessarily depend on each other and often there are several delay-cause criteria that affect the project schedule.

Regarding the content analysis, there are five main categories on which the questionnaire has been designed:

1. Manpower;
2. Raw materials and electro-mechanic systems;
3. Regulatory aspects;
4. Legal aspects;
5. Project's changes and complexity.

Conclusions

In the construction industry, execution delay means exceeding the length of performance from the date specified in the contract, or beyond the agreed-upon date for delivery of the project. The uncertainty leads to financial implications (Lo, et al., 2006). Outstanding claims relating to time are a contractor's requirement for an extension during the project, or an extension for a particular activity beyond the agreed duration, defining the delay in executing the project and its cost. Delays in the project timetables directly affect the project's budget, and the issue may become political in public projects.

The construction industry is an important economic sector for most developing countries. However, major infrastructure projects experience extensive timetable delays in the operational process. This study aims to identify the causes of timetable delays in the construction sector to assess and communicate their importance to all project stakeholders, the owner, the contractor, the consultant, etc. The literature has been extensively reviewed for the purpose of identifying the causes of delays and methods of minimizing timetable delays, while maintaining the quality, safety, and budget.

In a dynamic world that is changing from day to day, reality is the change. It is the incessant change. In this world, we have to manage construction projects with flexible methodologies that facilitate a change of the planning throughout the project execution. Research enables us to understand what are the main and meaningful factors that cause delays in the project timetables and are affected by changes to the project, whether these are global external factors, or changes due to customers' constraints.

This study outlines the problems that cause delays and the need to make construction projects flexible, fast, and suitable for frequent changes. Delaying timetables in construction projects is global and relevant worldwide, from India, Malaysia, Europe, the United States, to Israel. According to the literature, the main reasons for timetable delays in construction projects are

frequent changes associated with the order of work, an estimate of cost, and lack of budget in the project, the problem of raw materials and supply chains, and resource management in the project.

Managing projects by conventional methodologies, such as the Waterfall, is insufficient for coping with the changes. Moreover, the Agile methodology it not necessarily suitable to construction projects. Nevertheless, the global trend of delays in the delivery of projects indicates the need for a methodology that integrates both the Waterfall and Agile methodologies, providing a response to a quick decision-making in the field. A reality that changes every day, entails many challenges to the owners, contractors, consultants, and project managers. It is necessary to make quick decisions in short intervals, rather than expect the project's initial planning to be relevant even after a long, often years' long execution.

The findings of this study will leverage the development of a new model for construction projects management. The model will integrate the techniques and flexibility of the Agile methodology with the spatial and comprehensive vision of the Waterfall model to meet fast and changing timetables in construction and infrastructure projects. Moreover, the findings will support a different form of project management for construction projects, whereby project managers integrate several project management methodologies to accomplish the project goals. Project managers do not depend on the conventional Waterfall model for construction project management, but rather implementing and integrate Agile methodologies prevalent in the world of project management in other disciplines. Hence, the business vision and strategic understanding required from the managers may be beyond the managers' professional and technological capabilities.

With a critical path network, it is possible to determine compensation in time, and to some extent in cost, for the delays arising from any eventuality. The literature has often recommended the critical path method, but writers usually fail to discuss the problem of concurrent delays. Delays may be caused by several parties, contracting parties, or others. Consequently, the effects and remedies vary from case to case. Concurrent delays are two or more co-occurring delays and their resolution has always been challenging. The primary aim of this study is to present a method for dealing with this type of delay by means of the Agile methodology. An example will demonstrate the process effectiveness in determining the contracting parties' responsibility for project timetables.

Organizations are widely adopting agile methodologies to increase speed and provide flexibility for software development. The Agile methodology has numerous positive focuses. Although companies that considerably focus on the conventional project management process fear the complete adoption of this method, it may encompass a potential risk. It is not a "one-fits-all" arrangement, and, thus, we regularly see businesses utilizing a mix of methods and hybrid solutions. When organizations that have followed the Waterfall model have switched to pure Agile methodology, the transition has given rise to many issues.

The reason resides in the adaptability to a different approach and the incompetence to establish a suitable combination of a hybrid approach for construction projects that may lead to added unnecessary complications. This will help the organizations' transition from conventional PM (project management) methodologies to the Agile methodology. As with any other change, growth to a new process involves several issues. Hence, careful planning and study of the transition impacts of the transition, such as quality, timetable, budget and resources can help execute the change itself.

The mixed methods approach (conventional and Agile) allows companies to benefit from the agile methodology and to eliminate the issues with the conventional model. "Agile" is the most recent popular expression. Numerous organizations need to "put a finger in the water",

checking whether the agile methodology is suitable, without really changing their entire organizational structure to be flexible in a blaze-cut situation.

The cost of smart cities constructions with electromechanical systems and sophisticated technologies is very high, so it is important not to exceed the pre-defined timetables. Thus, by properly managing the activities, understanding the factors that affect schedule delays, and managing frequent changes and changing needs, construction projects can be kept ahead of them.

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CIRCULAR ECONOMY AND EUROPEAN SMART CITIES. INTERDISCIPLINARY PERSPECTIVES ON URBAN SUSTAINABILITY

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Abstract: Due to the exponential increase in greenhouse gas emissions, air pollution is one of the biggest challenges of the 21st century. The main causes of rising greenhouse gas emissions are industrial manufacturing processes and increased road traffic, which is not exactly friendly to the environment and human health. Cities, constantly affected by traffic congestion, are the starting point for viable, efficient, and sustainable solutions to reduce pollution. The objective of our paper is to analyze different aspects related to the circular economy, environmental protection, and smart city development in European Member states, over a 22-year period (2000-2021). We focus on this timeframe because throughout this period the world's population has experienced a multitude of events that have had a negative impact on many sectors (the 2008 financial crisis, the sovereign debt crisis, extreme weather events, and the COVID-19 pandemic). These events have highlighted the vulnerabilities of economic systems and demonstrated the importance of adopting sustainable approaches to urban development.

Keywords: renewable energy; smart cities; circular economy; COVID-19; European Union

JEL classification: O1, O44

Introduction

In the contemporary economy, people face many complex and interlinked challenges, such as global warming, environmental degradation, and rapid urbanization. Also, the COVID-19 pandemic has led to unprecedented challenges to public health, food system, employment, and labor issues. All these global challenges demand socially responsible, and environmentally friendly actions that meet the needs of the current generation, without compromising the ability of future generations to meet their own needs. In line with these statements, the transition from traditional cities to smart cities can be seen as an imperative necessity, in order to enhance public services such as healthcare and education, improve sustainability and the quality of life for residents, and reduce the environmental impact. Cities that 'aspire' to be 'smart cities of tomorrow' aim to address various urban challenges from traffic congestion, energy consumption, waste management, and public safety. In order to alleviate these issues, smart

cities are looking to technical solutions for a more sustainable future, such as: *smart grids* to optimize energy consumption and distribution, *smart lights* that allow cities to ensure illumination based on lighting demands, *smart parking management* based on in-ground vehicle detection sensors, which help identify a vacant parking spot, *environmental monitoring systems* that use different sensors to track ecological factors or smart transportation solutions (e.g. smart traffic signals that help reduce congestion and optimize traffic flow), among others. Some other benefits of smart cities may include early warning and rehabilitation of the community pre and post disasters: the disaster resilient cities are made "*through multi-sectoral and multi-stakeholder approaches along with policy level intervention*" (Magotra, et al., 2019). To make cities disaster resilient an efficient urban planning and smart growth strategies are needed, in order to prepare communities for potential threats and improve their capacity to recover (Magotra, et al., 2019; Lai, et al., 2020). One of the pioneers in promoting the smart city concept was the California Smart Community Institute, which focused on how cities plan to implement information technologies (Singh, et al., 2022). Of course, as the years have passed, this concept has developed more and more and has been widely adopted by many cities around the world. As technology advances, the smart city concept continues to become increasingly innovative, addressing the challenges it faces with technology and data-driven solutions. Smart cities initiatives play a crucial role in promoting the principals of circular economy: recycling, reusing, repairing, refurbishing, and remanufacturing among others. Integrating circular economy principles into a smart city framework helps to develop a sustainable, emission-free, and economically viable environment.

The objective of our paper is to analyze different variables related to circular economy and environmental protection and smart city development, namely: CO_2 emissions, renewable energy consumption, recycling rate of municipal waste, private investments related to circular economy sectors individuals using the internet, research and development (R&D) expenditure and unemployment rate, across 27 European Member states. These variables will provide a brief description of different aspects related to circular economy, environmental protection, and smart city development, and covers a 22-year period (2000-2021). We focus on this timeframe because throughout this period the world's population has experienced a multitude of events that have had a negative impact on many sectors (the 2008 financial crisis, the sovereign debt crisis, extreme weather events and the COVID-19 pandemic). These events have highlighted the vulnerabilities of economic systems and demonstrated the importance of adopting sustainable approaches to urban development.

The paper is structured as follows: in the next section, we present the literature review that focused on circular economy and on smart and sustainable cities. In the following sections, we describe the data and methods used in the research and then we present the results obtained from the analysis. After that, we present the most important conclusions.

1. Literature review

1.1. Defining circular economy

There have been several attempts to define the circular economy (**Table 1**). First, several authors focused on resource-oriented definitions, mainly on the reduction of resource consumption, pollution, and waste. For instance, Sauvé et al. (2016) defined circular economy as the "*production and consumption of goods through closed-loop material flows that internalize environmental externalities linked to virgin resource extraction and the generation of waste (including pollution)*'' (Sauvé et al. 2016, p. 49). On the other hand, other authors emphasize the concept as an "*alternative to a traditional linear economy (make, use, dispose of) in which we keep resources in use for as long as possible, extracting the maximum value from them whilst in use, then recovering and reusing products and materials*'' (Mitchell, 2015).

Other authors extend the understanding of the concept by incorporating how industrial systems are organized in accordance with the resilience principle through decoupling economic growth from material consumption, strengthening competitiveness, and providing opportunities to create well-being and employment (EEA, 2016; Kennedy and Linnenluecke, 2022). The concept of circular economy is recognized as redesigning products and services from their conceiving phase, which implies the economic and social systems' capacities to restructure and adapt to more sustainable beliefs.

Table 1. Circular economy definitions and sources

Definition (s)	Sources
"… a way of organizing industrial systems that support resilience through decoupling economic growth from material consumption".	Kennedy and Linnenluecke (2022)
"… describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations."	Kirchherr et al. (2017)
"… provides opportunities to create well-being, growth, and jobs, while reducing environmental pressures".	EEA (2016)
Represent the … "production and consumption of goods through closed-loop material flows that internalize environmental externalities linked to virgin resource extraction and the generation of waste (including pollution)".	Sauvé et al. (2016)
"… an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extracting the maximum value from them whilst in use, then recovering and reusing products and materials."	Mitchell (2015)

Source: Author's representation.

The above definitions incorporate the importance of decoupling economic activity from negative environmental impacts of production and consumption, through inter-connectivity and resource dependency among involved actors with the goal of eliminating waste and pollution, increasing the resource use capacity, and enabling multiple product life cycles, to the benefit of current and future generations (Kirchherr et al., 2017; Kennedy and Linnenluecke, 2022). Incorporating the circular economy principles in every business represents a way of fighting against scarcity of resources and volatile prices, and optimization of resource flows (European Commission, 2015).

Most definitions tend to incorporate the 3Rs to reduce the impact on the environment: *reduce* (prevent, consume less, and reduce waste), *reuse* (use things again, redistribute surplus or repair if possible), *recycle* (recycle as much as possible through composting; regulate disposals), an initiative developed by the Japanese Government in 2004. Later, the European Union's waste hierarchy included an additional R, which indicated the need to *recover* for other purposes (European Commission Waste Framework Directive, 2008). By 2017, through the

paper of Potting et al. (2017), 9R's initiatives have been identified as contributing to circularity (**Figure 1**). The new circularity strategies replace the end-of-life concept with a) smarter product use and manufacture; b) extension of the lifespan of the products and their components; and c) useful application of materials (Potting et al. 2017).

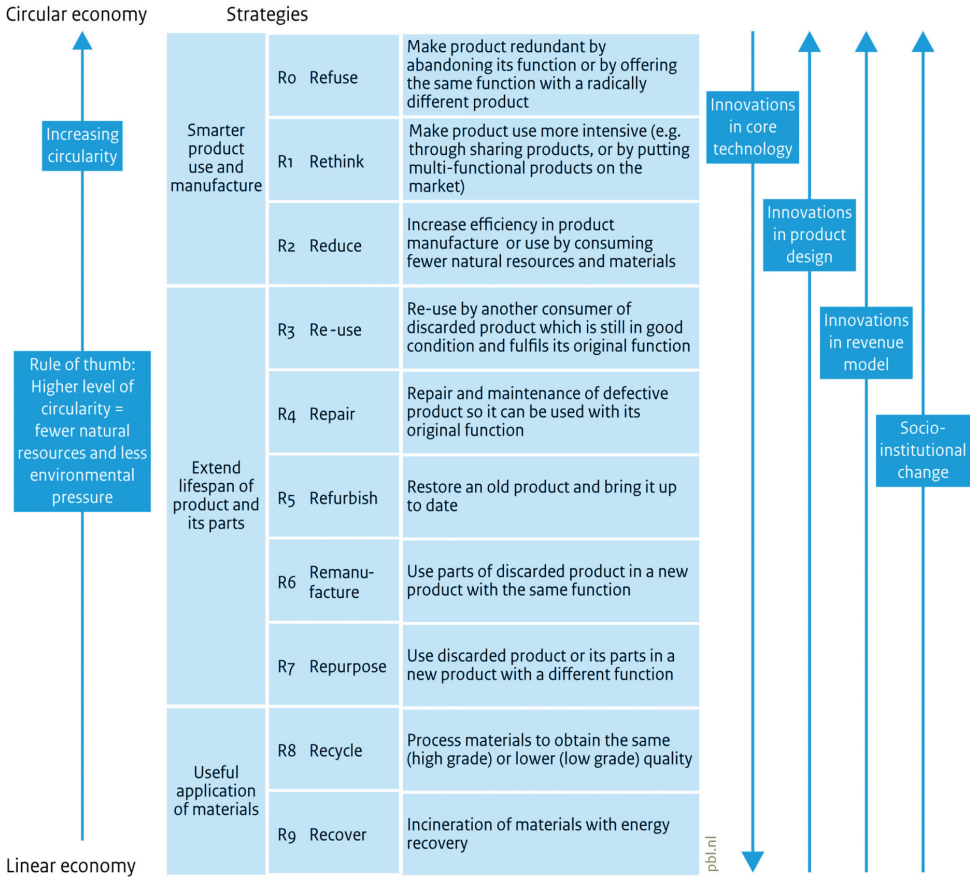

Figure 1. Circular economy strategies and initiatives

Source: Potting et al. (2017), p. 5

The transition to resource circularity is in line with the European Commission Action Plan (EC 2015; EC 2020), which indicates the necessity to develop a sustainable, low-carbon, resource-efficient, and competitive economy to reduce pressure on natural resources. The measures proposed in the Action Plan aimed at avoiding producing irreversible damage to nature, which exceeds its capacity to renew in terms of climate and biodiversity, air, soil, and water pollution. The main objectives in achieving the Plan agenda involve: making products more durable, reliable, reusable, upgradable, reparable, easier to maintain, refurbish and recycle (these eco-designed products should be considered as the norm, not the exception); empowering consumers and the public buyers; spotlight those sectors that have a high potential for circularity, and which consume most resources (e.g. electronics and batteries); minimizing the generation of waste; make circularity work for people, regions and cities and lead the efforts on circular economy at the global level (European Commission, 2020). The changes brought through the Action Plan for the Circular Economy are intended to contribute to the change in

the model of economic development: from a linear economy model towards a circular economy model.

By presenting solutions that emerge as a result of pressing cross-cutting sustainable development challenges, the circular economy holds particular promise for achieving multiple Sustainable Development Goals (SDGs): clear water and sanitation (SDG 6); Decent work and economic growth (SDG 8); Sustainable cities and communities (SDG11); Responsible consumption and production (SDG12); Climate Action (SDG 13), Life below water (SDG14) and Life on land (SDG 15). This can be achieved at all levels of operations: at the micro level (products, companies, and consumers), meso level (eco-industrial parks), and macro level (city, region, nation, and beyond) (Kirchherr et al. 2017).

In terms of regulations several directives have been promulged, which frame the need to progress towards a more circular economy: Regulation (EU) 2018/848 (e.g. organic production principals and rules), Directive (EU) 2018/849 (e.g. obligations on End-of-Life Vehicles, Batteries and Accumulators and Waste Batteries and Accumulators), Directive (EU) 2018/850 (landfill of waste), Directive (EU) 2018/851 (makes amendments to Directive 2008/98/EC on waste (the Waste Framework Directive) which provides the legislative framework for the collection, transport, recovery, and disposal of waste; supports the broader EU circular economy initiative, which aims to move the European economy toward sustainable production and consumption) or Directive (EU) 2018/852 (sets out the EU's rules on managing packaging and packaging waste – designed to prevent the waste).

Besides the European Directives related to circular economy, particular attention should be paid to the educational system, as a catalyst to boost citizens and corporations' awareness of the measures that can contribute to improving the environmental quality: e.g., education on garbage classification, on how to reduce carbon emission or energy savings, among others. In this sense, governments can significantly contribute to achieving sustainability by applying well-organized and coherent environmental management, using renewable energy, and promoting sustainable tourism and, depending on rising the institutions' performance in charge with the supervision and monitoring of all the targeted activities (Dincă, et al., 2022).

1.2. Circular economy and cities

Three main principles which govern the circular economy are considered: a) design out waste and pollution; b) keep products and materials in use; and c) regenerate nature (European Commission, 2018). For cities and regions, the circular economy allows rethinking production and consumption models, services, and infrastructures by making efficient use of natural resources, and more sustainable consumption and production (Ellen MacArthur Foundation, 2019a). By 2050, two out of every three people are likely to live in cities or urban centers, which indicates the necessity for more sustainable urban planning and public services (UN Report, 2018). Cities produce 50% of the global waste (Ellen MacArthur Foundation, 2019b,), and release up to 70% of greenhouse gas (GHG) emissions (WEF, 2021), out of which 52% is produced by only twenty-five mega-cities, sharing a big responsibility for the decarbonization of the global economy and waste reduction (WEF, 2021). With the shifts in consumption patterns, nowadays more than 80% of food is consumed in cities (EAT Cities, 2022). As we can see cities represent the places where people live, work, consume, and dispose of, which underlines their fundamental role in the transition to the circular economy, as a catalyst in reducing the negative impact on the environment through pollution decrease, depletion of raw materials, water, and land, and an increase in renewable energy capacity and use, among others.

From driverless cars or buses to automating people's morning routines using Siri, Alexa or Google Assistant, cities are becoming smart not only when it comes to automation of routine functions but also in terms of monitoring, understand, analyses and plan the city to improve

the efficiency, equity, and quality of life for its citizens (Dincă, et al., 2022). This shift in individual's lifestyle can be seen as an opportunity to encourage measures that address climate chance and reduce the impact on the consumption of resources. The future urban systems should be built on the principles of circularity (4Rs), to guarantee future generations, the same resources as previous ones and to ensure the well-being of the entire ecosystem.

A well-defined vision of successful initiatives to create a smart and sustainable city is imperative. Most of the time, city authorities and policy makers use one or more smart city indicators depending on the objective they have in the implementation of their own projects (Emrouzeh et al., 2019). In this context, some researchers have classified these indicators into six main groups which are presented in **Table 2** (Chourabi, et al., 2012; Piro, et al., 2014; Neirotti, et al., 2014; Anthopoulos, 2015).

Table 2. Smart city indicators and sub-indicators.

Indicators	Sub-indicators
Smart Economy	- Innovations and strategic investment; - Economic opportunities; - Knowledge Economy; - Local & global interconnectedness; - Education.
Smart People	- Level of qualification; - ICT skills; - Embrace creativity; - Cosmopolitanism.
Smart Governance	- Integrated Management; - Strategies and perspectives of smart city development; - Public and social services.
Smart Environment	- Efficient use of water; - Management and protection of natural resources; - Green buildings; - Green urban planning; - Use of renewable energy sources.
Smart Living	- Economic welfare; - Touristic attractiveness; - Culturally vibrant & happy; - Healthcare.
Smart Mobility	- ICT Infrastructure; - The innovative transport system, non-motorized vehicles; - Mixed-modal access; - Clean & non-motorized options; - Local accessibility.

Source: Adapted from Smart City Index Master Indicators Survey.

In **Table 2** are presented Smart city indicators and sub-indicators, which encase different aspects related to technology and infrastructure, socio-cultural contexts, and quality of life, among others. In this context, the **"smart economy"** indicator focuses on the sustainable growth of cities, capturing issues that take place within cities (human capital, innovativeness, infrastructure, education). The second indicator entitled **"smart people"** aims to transform the way citizens interact with the public and private sectors. This indicator also addresses smart forms of education to facilitate career choices, training, including lifelong learning for all ages. **"Smart environment"** describes all activities that address the city's impact on the

environment. During the transformation process, smart cities face various challenges. Therefore, *governance* mechanisms are needed to facilitate the creation and implementation of effective public policies (Petrova-Antonova, 2018). Therefore, **"smart governance"** is based on good governance, such as open, participatory, accountable principles and e-government (Lopes, 2017). In a broader sense, 'smart government' refers to strengthening the relationship between government and stakeholders (citizens, businesses, etc.). **"Smart living"** aims to increase the quality of life of citizens and improve social and digital inclusion, while **"smart mobility"** focuses on increasing the efficiency and quality of urban transport services to improve the use and adoption of new mobility solutions (**Table 2**).

2. Sample, Data, and Methodology

The main objective of the paper is twofold: firstly, to present how circular economy contributes to the sustainable development of smart cities in terms of resource efficiency and reducing waste, which are closely interlinked with the smart cities guiding principles; secondly, we will take into consideration the importance of the renewable energy consumption in the development of smart cities across the European Union.

Our analysis focuses on EU Member States, namely Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden, and covers a 22-year period (2000-2021). We focus on this timeframe because throughout this period the world's population has experienced a multitude of events that have had a negative impact on many sectors (the 2008 financial crisis, the sovereign debt crisis, extreme weather events and the COVID-19 pandemic). These events have highlighted the vulnerabilities of economic systems and demonstrated the importance of adopting sustainable approaches to urban development. In this context, **Table 3** presents the description of the variables we considered in our analysis, abbreviations and data source. For the present research, we included several variables, namely: CO_2 emissions, renewable energy consumption, recycling rate of municipal waste (as % of GDP), private investments related to circular economy sectors (as % of GDP), individuals using the Internet (as % of total population), research and development expenditure (as % of GDP) and unemployment rate. These variables provide a brief description of different aspects related to the circular economy, environmental protection, and smart city sustainable development.

Table 3. Description of the variables and data sources.

Variables Abbreviation	Description	Data Source
CO_2 emissions	CO_2 emissions (metric tons per capita)	The World Bank
REC	Renewable energy consumption (% of total final energy consumption)	The World Bank
RRMW	Recycling rate of municipal waste (Thousand tons)	OECD
PICE	Private investments related to circular economy sectors (% of GDP)	Eurostat
Internet	Individuals using the Internet (% of population)	The World Bank
R&D	Research and development expenditure (% of GDP)	The World Bank
Unemploy	Unemployment, total (% of total labor force)	The World Bank

Source: Authors' elaboration based on empirical studies.

From a methodological point of view, we have been using descriptive statistics to underline the basic features of the data in our study. We applied descriptive techniques as means or standard deviation to show importance differences across countries.

Table 4 presents the statistical description of the variables used in the analysis for the 27 EU Member States.

Table 4. Descriptive statistics of the variables.

Variable	Obs.	Mean	Std. Dev.	Min	Max
CO_2 emissions	567	7.512049	3.50908	2.926895	25.61044
REC	544	16.82473	11.6298	0.09	52.88
RRMW	583	29.68854	18.25991	0.2	71.1
PICE	459	0.6638344	0.3497337	0.1	2.4
Internet	593	62.89913	24.35759	3.613717	98.86585
R&D	561	1.474143	0.8944794	0.2269	3.8738
Unemploy	594	8.556263	4.334001	1.81	27.47

Source: Own calculations.

The standard deviation summarizes how the values of each variable are dispersed in relation to the mean. The results from the analysis indicate that the lower values for CO_2 emissions were registered in Latvia (2.926 in 2000), followed by Malta (2.969 in 2016) and Lithuania (3.004 in 2000). The highest values were registered in Luxemburg (25.610 in 2005). Renewable energy consumption (% of total final energy consumption) indicates that the highest values are registered in countries like Sweden and Finland, while the lowest values are registered in Malta and Luxemburg. There is a significant difference in the recycling rate of municipal waste, ranging from a minimum of 0.2 (Romania, 2000) to a maximum of 71.1 (Germany, 2021). We believe that this difference is explained by public awareness of the importance of recycling, investment in research and development, including government policies and infrastructure. In this respect, some EU countries are equipped with modern infrastructure and advanced recycling technologies, allowing them to recycle a large proportion of waste. For example, it is well known that Germany is celebrated as a world leader in recycling. In recent years, it has adopted highly effective mandatory waste sorting policies, leading to improved waste management. In contrast, Latvia, Lithuania, and Romania at that time did not have a highly developed infrastructure for waste collection and recycling. In terms of private investments related to circular economy sectors (% of GDP), the lowest percentage allocated is registered in Greece and Ireland, while the highest one is registered in Austria. The internet (can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV among others) plays a key role in everyday life, and in the development of a sustainable and efficient urban environment. The analyses show an increase in most countries during the last years, with the highest values registered in Luxemburg and Denmark. In countries with less developed economies, the *amounts* that governments agree *to* allocate for *R&D* as part of their budgetary plan, is much lower. However, in Estonia, Slovenia, Romania, and Hungary, although the GDPs level is lower than in other EU countries, the investment rate in R&D is still high. In the recent years, the most affected countries by unemployment were Greece and Spain. However, most countries register high unemployment rate during the financial crises and COVID-19 pandemic effects.

3. Results and interpretation

Figure 2 shows the fluctuation of carbon dioxide emissions over the period 2000-2021 for all 27 EU countries, where we can see a decreasing trend towards the end of the period under analysis. At European level, developed countries tend to have higher emissions compared to less developed ones.

Figure 2 indicates that Luxembourg enters into the category with the highest CO_2 emissions, although from 2005 onwards it shows a downward trend until the end of the period analyzed. This is justified by the fact that the country's population was at that time very rich and energy consumption per capita was high. Also, the country's steel industry and huge sales of fossil fuels for transport contributed to this increase during 2000-2011 (International Energy Agency, 2000). Things have now changed significantly for Luxembourg (European Parliament, 2021). According to binding European legislation in climate and energy requires Member States to adopt National Energy and Climate Plans (NECP) by 2030. In this context, the National Energy and Climate Plan in Luxembourg was finalized in May 2020. Luxembourg has set itself a very ambitious target of reducing greenhouse gas (GHG) emissions by 55% by 2030 compared to 2005 levels and aims to achieve net zero emissions by 2050.

Figure 2 also shows the fluctuating trend in Estonia over the period under review. One reason for Estonia's fluctuating trend is due to oil shale, an energy-rich sedimentary rock that is similar to coal. This oil shale covers the country's energy needs, supporting its energy independence. Moreover, Estonia's buildings, more than two-thirds of which were built before independence from the Soviet Union, are relatively energy inefficient and contribute to greenhouse gas emissions (OECD, 2022).

In order to achieve a 'clean' economy, Estonia has committed to a 70% reduction in emissions by 2030 and an 80% reduction in 2050 compared to 1990 levels.

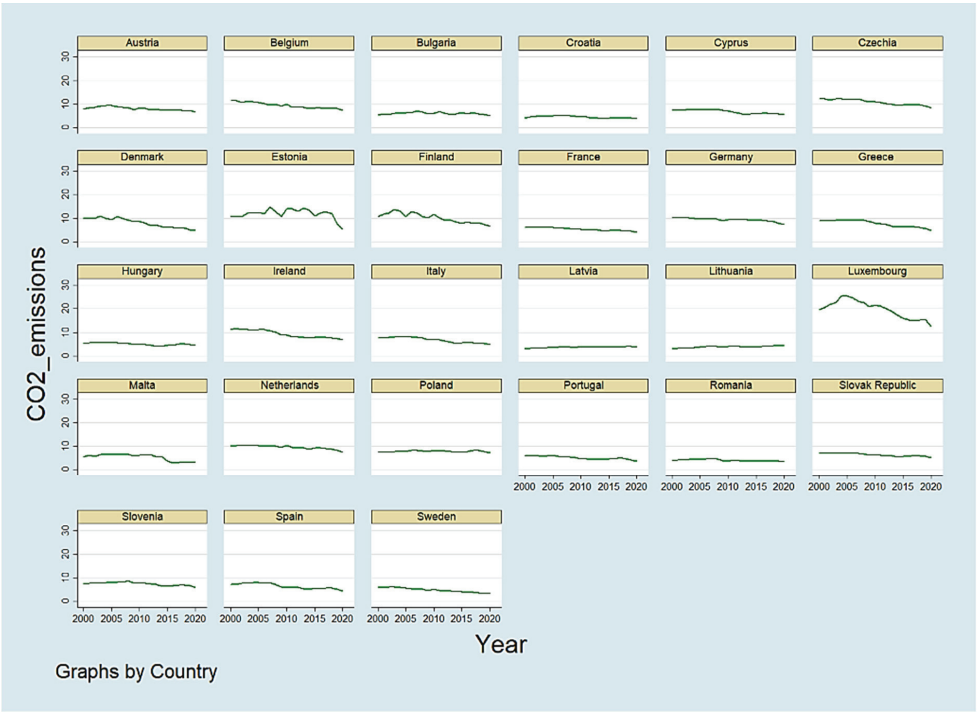

Figure 2. Evolution of CO_2 emissions in the EU Member States, 2000-2021.

Source: Own representations.

Looking at all the graphs, there is a huge drop in CO_2 emissions in 2020, largely due to measures implemented by national governments (closing borders, sealing off the population, closing schools) to limit the spread of the COVID-19 pandemic. Substantial amounts of CO_2 emissions from road and non-road transport disappeared virtually overnight. Given that the last

year of our analysis is 2021, it is not yet very clear to us how things will unfold in terms of CO_2 emissions. But nevertheless, according to analysis by the Global Carbon Project, CO_2 emissions have recovered and will approach global emissions in 2019 (Global Carbon Project, 2021). **Figure 3** shows the evolution of renewable energy consumed for EU member states, during 2000-2021.

In recent years, the development of renewable energy systems has intensified, and various factors such as political, financial, and geographical factors have contributes to it. For example, in the category of geographical factors, Sweden has a huge energy potential from the development of wind and nuclear energy, due to its topography that allows the maximum exploitation of this type of energy, and the upward trend towards the use of renewable energy is also evident in the graph (see **Figure 3**). Sweden has a percentage of 39.82% at the beginning of the analysis and 52.88% at the end of the period under review. Although there is no significant dependence in total energy production, Sweden is among the users of biomass and biogas energy. This is also the case for Austria, which has developed its hydropower industry, providing a high percentage of the country's energy needs.

The main objective of all EU countries is to reduce CO_2 emissions. So, as the picture above suggests, every EU country is making positive progress in the use of renewable energy, but progress varies from country to country. In this context, Malta has a 7.7% share of renewable energy use in 2019. Of course, there are a lot of factors contributing to the low rate of renewable energy use. First, Malta is a small, island state and is limited in terms of natural resources. Also, Malta relies heavily on imports of fossil fuels to meet its energy needs. Despite this, the government has recognized the importance of implementing renewable energy for creating a sustainable environment and has started to take various measures to improve the situation. To this end, plans have been developed to increase the use of solar and wind energy.

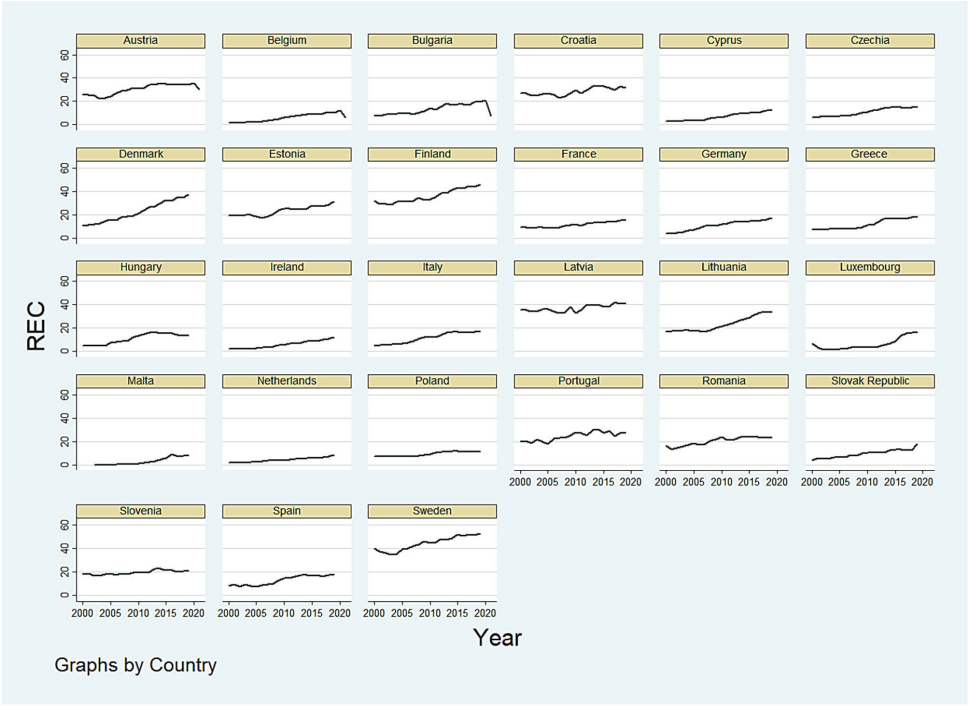

Figure 3. Evolution of renewable energy consumption in EU Member States, 2000-2021.

Source: Own representations.

With the increased use of renewable energy sources, there has been a considerable body of literature examining the relationship between renewable energy consumption and economic growth. Currently, the literature closely related to this topic is based on the following two streams. There are some studies that have found no relationship between renewable energy consumption and economic growth (Menegaki, 2011; Chang, et al., 2015), while others have found that renewable energy consumption leads to increased economic growth (Bhattacharya, et al., 2016; Inglesi-Lotz, 2016; Bulut and Muratoglu, 2018).

At the end of 2015, the European Commission started implementing the transition towards a circular economy by adopting a package of measures consisting of an action plan and proposals to revise waste legislation. In this context, investment plays a crucial role in the progress towards a sustainable, socially and environmentally responsible economy. As climate change concerns have received increasing attention in recent years and resource depletion has increased substantially, private investment has become increasingly important. In **Figure 4** we have illustrated the average private investment from 2000-2021 in order to observe its fluctuations in different economic periods (2008 financial crisis, COVID-19 pandemic).

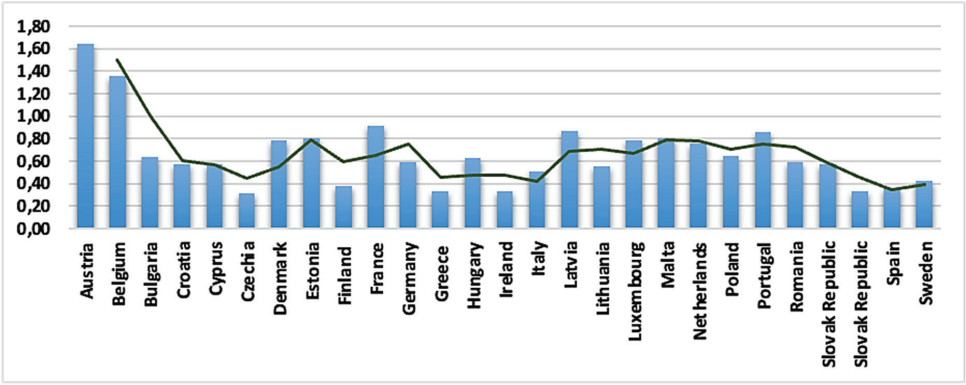

Figure 4. Private investment in the circular economy sector, European Union, 2000-2021

Source: Own calculations.

According to the attached graph, we can admit that the progress being made by each country suggests that both governments and the financial sector are committed to the transition to the circular economy. In this sense, cities have a significant role to play in the transition towards a circular economy. As cities are home to the largest part of the population, they generate a huge amount of waste. Of course, this has led to a shift from a traditional "make, use, throw away" society to a "reduce, reuse, recycle" society. In this way, products are maintained at the highest level of value and usefulness and resources are used in the most efficient way, while waste generation is minimized.

Figure 4 shows that, Austria has the highest level of private investment. As we all know, in recent years, Austria has been one of the European Union countries with a strong commitment to work towards developing the circular economy and encouraging investment in this area. Among the factors that have contributed to this rate of private investment are government policies to support the circular economy, the implementation of different technologies, public-private partnerships. As a result of these continuous efforts, the Austrian government has become a successful example of moving towards a sustainable circular economy. At the other end of the spectrum, the Czech Republic has the lowest rate of private investment in the circular economy sector of all countries surveyed.

We believe that investment in the circular economy should be at the top of governments' agendas, as it has huge potential to mitigate environmental degradation and improve resource efficiency. De Jesus and Mendonça (2018) found that investment in the circular economy sector has a strong positive impact on the circular economy. Of course, with the help of private investment, smart cities can benefit from smart technology solutions that will improve the quality of life of citizens.

According to data provided by The World Bank, the internet has become a driving force for economic change in recent years, and its high usage rates have grown exponentially (**Figure 5** and **Figure 6**). In 1995 only 1% of the global population had access to the Internet, whereas today this rate has exceeded 60% of global users.

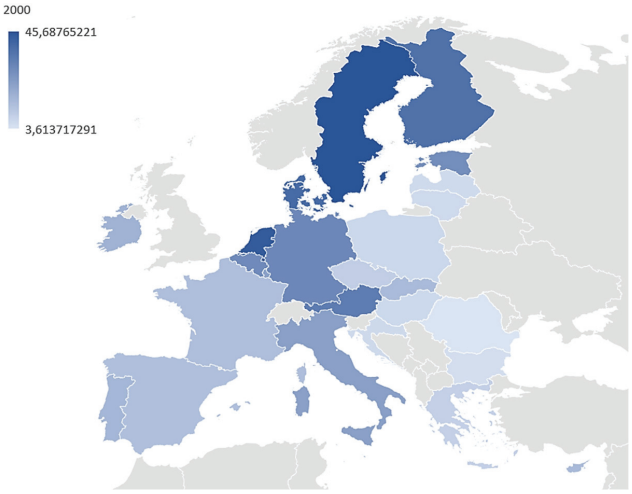

Figure 5. Internet usage in 2000, European Union

Source: Own representations.

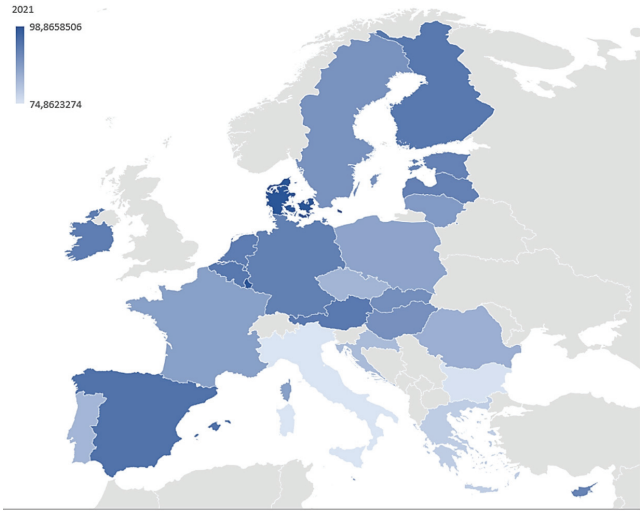

Figure 6. Internet usage in 2021, European Union

Source: Own representations.

Technological progress has led to mass adoption of the internet as its benefits have become pillars of the digital economy. Among the factors that have contributed to the exponential growth in internet usage rates is the pandemic crisis generated by COVID-19 (2020). Both restrictions imposed by national governments and international trade restrictions have facilitated the need for the development of internet infrastructure and the equipment used, leading to economic growth in IT equipment producing countries. During the pandemic crisis, the internet became the main channel for communication and for all activities that could be carried out remotely.

Analyzing **Figure 5** and **Figure 6**, we believe that the Internet infrastructure will develop more and more, and Internet usage rates will increase much more as time goes by. However, this sector also faces challenges such as security issues, lack of advanced digital education among citizens, or internet access restrictions due to imposed regulations (Iran, Iraq, Turkey, China, North Korea, etc.). In this era of digitization, the internet plays a key role in everyday life, and in the development of a sustainable and efficient urban environment. In this context, smart cities use digital infrastructure to provide citizens a better environment. Areas where the internet is making its mark are moving towards a global communications infrastructure that enables them to be connected locally and globally, the internet of things (IoT), energy efficiency and sustainable resources, including various smart services for citizens.

In addition to the crucial role that the internet plays in the development of smart cities, research, and development (R&D) expenditure is also playing a significant role in the successful implementation of various innovative solutions to meet the needs of citizens and the specific challenges of smart cities.

If we look closely at **Figure 7**, we can see that R&D spending has register an upward trend in all EU Member States throughout the period analyzed, reaching a record level of around $1.7 trillion in 2001. This outcome is in line with the Sustainable Development Goals (SDGs), according to which, the world's countries have committed to substantially increase public and private spending on R&D by 2030 (UNESCO, 2022). In contrast, at the European Union level, according to reports published by Eurostat, €328 billion was spent on R&D in 2021 (2.27% of GDP). During the period under review, a large share of R&D spending was in the business sector, followed by the higher education sector.

The fluctuating trends that can be analyzed in **Figure 7** are due to differences in the level of expenditure and investment in the private business sector. This indicates that there is a strong correlation between the degree of economic development and investment in innovation and R&D. Often, countries with a developed economy are more willing to direct considerable resources to Research and Development (R&D). In order to maintain their competitive advantage in the global market and to constantly improve their services, these countries invest heavily in technology, which subsequently brings a number of benefits, including an increase in the rate of internet use across the European Union, as seen in **Figure 6.** On the other hand, in countries with less developed economies, the *amounts* that governments agree *to* allocate for *R&D* as part of their budgetary plan, is much lower. However, in Estonia, Slovenia, Romania, and Hungary, although the GDPs level is lower than in other EU countries, the investment rate in R&D is still high.

A sub-indicator of the smart economy index is the total unemployment rate. The unemployment rate is generally an indicator that affects work performance, including the health of the whole economy. With the progress of smart cities, as mentioned earlier, new economic and social challenges arise, and the unemployment rate is one of the most important. Ménascé et al. (2017) argue that the development of smart cities fosters an exponential growth of work through digital platforms such as Deliveroo, Uber, and Helpling.

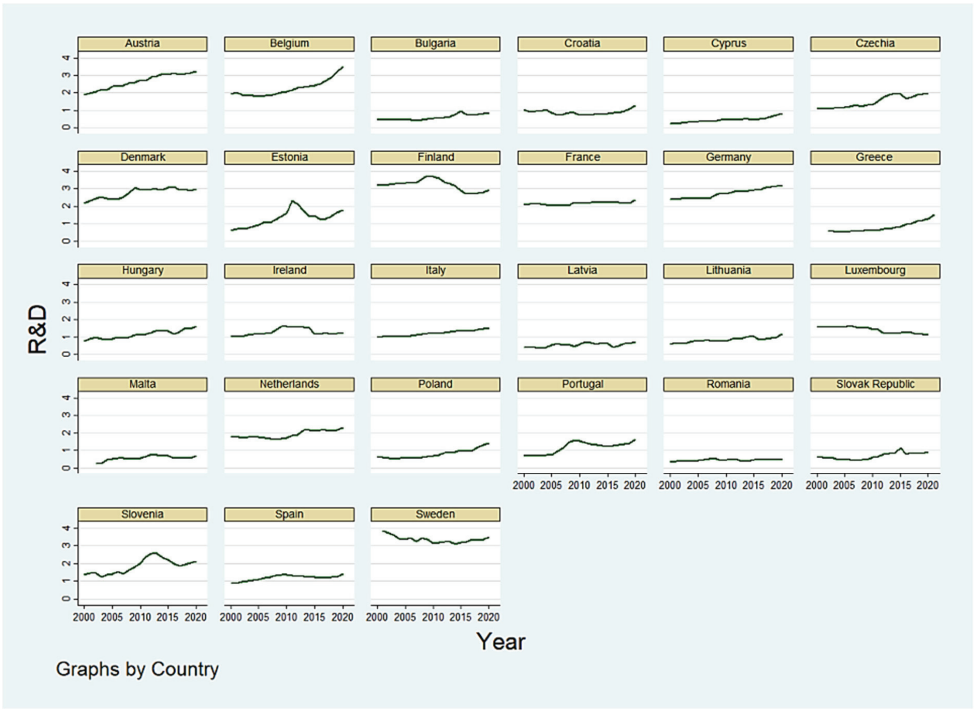

Figure 7. Evolution of R&D expenditure, European Union, 2000-2021

Source: Own representations.

Figure 8 highlights the oscillating trends in the overall unemployment rate for the whole selected sample. We have chosen to highlight also 2008 to better capture the effects of the financial crisis on the unemployment rate. The year 2021 also reflects the effects of the pandemic crisis on unemployment.

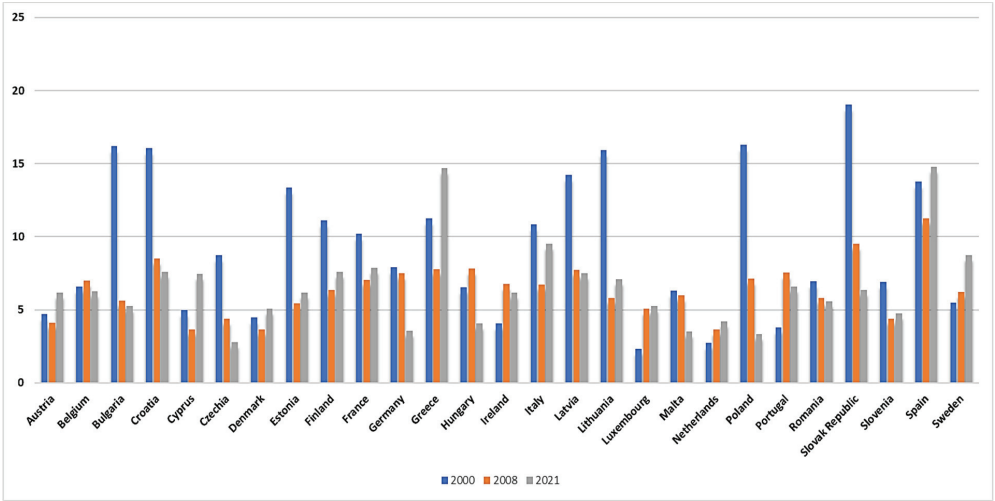

Figure 8. Evolution of unemployment, European Union, 2000 vs. 2008 vs. 2021

Source: Own representations.

The ***2008*** financial ***crisis*** began with cheap credit and lax lending standards that fueled a housing bubble, and severely affected most of the European countries; the hardest affected sectors were construction and finance. Unemployment has been rising sharply in the European Union (EU) since *2008* as a result of the global economic *crisis.*

As can be seen from **Figure 8**, the unemployment rate has shown fluctuating trends across the EU Member States, varying greatly from country to country depending on the level of economic development, the measures adopted at the time by national governments to support employment and fiscal policy. We note that the Nordic countries (Denmark, Finland, and Sweden) recorded lower unemployment figures in 2008, despite being developed economies. In contrast, the southern and eastern EU countries had higher rates.

Of course, just when everyone thought things were going to get back to normal, a new 'crisis' involving the debt levels of sovereign nations began in Europe. This event was another negative economic shock that started in Greece and continued in other countries, especially in southern Europe, leading to even lower unemployment figures. Having been hit very hard by the sovereign debt crisis, Greece has an unemployment rate of around 14.71% at the end of 2021. Just when things have started to get back to normal and humanity has started to adjust to post-crisis life, an event in China starts to disturb their peace. In the year 2020, the world is hit by the COVID-19 pandemic, and it will affect all areas of our lives at a rapid pace. The COVID-19 pandemic has led to massive job losses (between March and April 2020, more than 20 million jobs lost) and unemployment has reached its highest level since the 2008 crisis, affecting economic growth. As can be seen from **Figure 8**, in 2021, the most affected countries in terms of unemployment rate were Spain (with a rate of 14.78% of the total workforce) and Greece (14.71% of the total workforce), followed by Italy with a rate of 9.5%.

The restrictions that have been imposed by national governments have significantly affected both the public and private sectors, which have ultimately had a considerable impact on the labor market. At the other end of the spectrum, countries with low unemployment rates include Malta (with an unemployment rate of 3.53 at the end of 2021, compared to 4.35 in 2020), Germany, the Netherlands, Poland, including Slovenia. It is vitally important to learn from past events and focus on building resilient and sustainable economies to cope successfully with potential economic shocks.

Conclusions

The objective of our paper was to analyze different variables related to circular economy and environmental protection and smart city development, namely: CO_2 emissions, renewable energy consumption, recycling rate of municipal waste, private investments related to circular economy sectors individuals using the internet, research and development (R&D) expenditure and unemployment rate, across 27 European Member states. These variables will provide a brief description of different aspects related to circular economy, environmental protection, and smart city development, and covers a 22-year period (2000-2021). We focus on this timeframe because throughout this period the world's population has experienced a multitude of events that have had a negative impact on many sectors (the 2008 financial crisis, the sovereign debt crisis, extreme weather changes and the COVID-19 pandemic). These events have highlighted the vulnerabilities of economic systems and demonstrated the importance of adopting sustainable approaches to urban development. Through the analyses carried out, it has been brought to the fore that this transition to smart cities simultaneously develops huge opportunities for the use of renewable energy sources, while reducing carbon dioxide emissions. Achieving a real and easily implementable circular economy in urban areas can also be obtained in the following ways: (1) raising public awareness of the need for selective waste collection, (2) centralized access to databases or information portals for those interested in the

extent and implementation of the circular economy, and (3) efficient use of resources, both locally and nationally.

Embedding the circular economy in smart city strategies is a promising way towards a sustainable future. With the help of technology and citizens, smart cities can promote circular practices that increase resource efficiency, protect the environment and social well-being. The embrace of the circular economy by smart cities demonstrates commitment to global efforts to combat climate change and promote a healthy environment for future generations. A "circular" city should carry out its entire restructuring process in several stages. *First*, it could create smart and sustainable energy systems to begin with, and then move on to more challenging systems (e.g., smart water management systems). *Second,* in order to manage water as efficiently as possible and to avoid depleting natural resources, policymakers should consider implementing various intelligent systems to monitor water, as well as leak detection technologies. Thirdly, these cities could create new jobs to help reduce unemployment rates. We think it is appropriate for a smart city to take steps step by step, so it will become a circular city that works perfectly based on intelligent use of natural resources.

In addition, research results have shown that the implementation of renewable energy sources (solar, wind, hydro or biogas) in smart cities brings multiple benefits and can contribute to sustainable development. It goes without saying that the shift to renewable energy sources faces a lot of challenges (fluctuations in production caused by weather and the development of infrastructure to store energy).

So far, most EU countries have not yet developed an appropriate infrastructure for efficient waste management, which shows the importance of setting clear and binding long-term policy objectives to help implement measures and make investments more efficient.

Our research has certain limits related to the structure of the sample and indicators taken into consideration. First, our analysis includes only the EU member states in the analysis. The inclusion of other third countries in the analysis could be considered in the future, to broaden the perspective and relevance of the research in the field. Second, additional indicators could be considered, in order to better explain both circular economy and smart city development. As future research directions, the concept of smart cities as innovation laboratories could be explored, which would lead to the promotion of sustainable development.

Acknowledgements: This work was supported by Jean Monnet Module "European Smart Cities for Sustainable Development"—SmartEU, co-funded by the European Union (620415-EPP-1-2020-1-RO-EPPJMO-MODULE) and the Faculty of Economics and Business Administration, Alexandru Ioan Cuza University of Iași, Romania.

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LEVERAGING MACHINE LEARNING TO UNVEIL THE KEY DETERMINANTS OF WASTE MANAGEMENT IN SMART CITIES

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Abstract: Unravelling the complex dynamics of waste management in smart cities, this study harnesses the power of machine learning to identify critical influencing factors. With a focus on an array of waste types – including ferrous and non-ferrous metals, food, glass, and construction & demolition waste – our research employs a multifaceted machine learning approach. The analysis begins with an Ordinary Least Squares (OLS) regression model, which impressively accounts for 85.4% of the variance in total waste generation, as measured in thousands of tones. Notably, 'Food' waste type emerges as a significant predictor. Beyond these initial findings, the study employs additional machine learning methodologies to not only validate the OLS model's outcomes but also to unearth further insights into the intricate system of waste management in our cities of the future. This comprehensive analysis, straddling multiple algorithms, ensures the robustness of our findings and paves the way for data-driven waste management strategies in smart cities, contributing to more sustainable urban environments.

Keywords: Machine Learning; Waste Management; Smart Cities; Waste Generation; Predictive Modeling

JEL classification: Q53, Q55, R41

Introduction

The rapid urbanization of the 21st century has brought about a multitude of challenges, one of the most pressing being waste management in burgeoning urban areas. Smart cities, characterized by the integration of digital technology and urban planning, are at the forefront of innovative solutions to these challenges. However, the complexity of waste management in these environments requires a nuanced understanding of the underlying determinants that influence waste generation and disposal (Bibri & Krogstie, 2017).

Leveraging machine learning to analyze and predict waste management patterns is a novel approach that holds significant promise. Machine learning, a subset of artificial intelligence, has been successfully applied in various fields such as healthcare, finance, and transportation (Jordan & Mitchell, 2015). Its application in waste management is an emerging area of research that can provide valuable insights into the dynamics of waste generation, collection, recycling, and disposal (Kumar, et al., 2016).

Smart waste management is an important aspect of building sustainable and efficient cities. Recent research has explored the use of machine learning and deep learning techniques to improve waste management systems. One such study proposed a deep learning-based small object detection and classification model for garbage waste management in smart cities and

IoT environment (Alsubaei et al., 2022). The proposed model focuses on detecting and classifying small garbage waste objects to assist intelligent waste management. Another study explored the use of machine learning for a circular economy with waste recycling in smart cities (Chen, 2022, Fang 2023). The study proposed a machine learning approach to optimize waste recycling in smart cities. A review of the literature on artificial intelligence for waste management in smart cities found that deep learning models have been used for waste detection and classification (Gue et al., 2022). The review also highlighted the use of convolutional neural networks (CNNs) for waste sorting and the use of IoT devices for smart waste management. Other studies have explored the use of machine learning algorithms for predicting waste management system performance (Namoun et al., 2022) and for solid waste generation and disposal (Xia et al., 2022). Overall, machine learning and deep learning techniques have shown promise in improving waste management systems in smart cities.

This study aims to contribute to this burgeoning field by employing a multifaceted machine learning approach to identify the key determinants of waste management in smart cities. By focusing on various waste types, including ferrous and non-ferrous metals, food, glass, and construction & demolition waste, we seek to unravel the intricate system that governs waste management in urban environments.

The initial analysis, using an Ordinary Least Squares (OLS) regression model, provides a robust foundation for understanding the variance in total waste generation. The subsequent application of additional machine learning methodologies not only validates the initial findings but also uncovers deeper insights into the complex dynamics of waste management.

The significance of this research lies in its potential to inform data-driven strategies for waste management in smart cities. By identifying the critical factors influencing waste generation and management, policymakers, urban planners, and waste management professionals can develop targeted interventions to enhance sustainability and efficiency in urban environments (Cheng, et al., 2018).

In the following sections, we will delve into the methodology, data collection, analysis, and findings of this study, culminating in a comprehensive understanding of how machine learning can be harnessed to unveil the key determinants of waste management in smart cities.

1. Methodology

The methodology employed in this study consists of a series of data pre-processing, statistical analysis, and machine learning modelling steps, aimed at identifying the key determinants of waste management in smart cities. Below, we detail the various stages involved in the analysis:

1.1. Data Collection and Pre-processing

The dataset used in this study was collected from the years 2018 to 2020 and includes various attributes related to waste types, including ferrous and non-ferrous metals, food, glass, and construction & demolition waste. The CSV file containing this data was imported into a Pandas Data Frame for further analysis. The categorical variable 'Waste Type' was transformed into dummy variables to facilitate the regression analysis.

1.2. Exploratory Data Analysis (EDA)

Initial exploration of the dataset was conducted to obtain descriptive statistics and understand the distribution of the variables. This step aided in identifying potential patterns and relationships within the data that guided subsequent analyses.

1.3. Ordinary Least Squares (OLS) Regression

A linear regression analysis was carried out using the Ordinary Least Squares (OLS) method to model the relationship between waste generation (measured in thousands of tons) and the predictors. Two separate models were fitted, one with the 'Waste Type' and 'Total Recycled' attributes, and the other with only the 'Waste Type' feature. The regression results provided valuable insights into the significance of the predictors and the percentage of variance explained by the models.

1.4. Machine Learning Models

The methodology snippet provided does not include details about the specific machine learning models employed beyond the OLS regression. However, as described in the abstract, additional machine learning methodologies were utilized to validate the OLS model's outcomes and unearth further insights. These methodologies may have included various regression, classification, and clustering techniques that were cross-validated and evaluated based on relevant metrics.

1.5. Data Splitting for Model Validation

Although not detailed in the code snippet, it's customary in machine learning studies to split the data into training and testing sets. This approach ensures that the models are evaluated on unseen data, enhancing the robustness of the findings.

The methodology employed in this study represents a comprehensive and multifaceted approach to unravelling the complex dynamics of waste management in smart cities. By combining traditional statistical techniques with cutting-edge machine learning methodologies, the study offers a robust analysis that contributes to the understanding of waste management determinants and informs data-driven urban planning strategies.

2. Results

The results of this study unveil key insights into the determinants of waste management in smart cities, leveraging a multifaceted machine learning approach. The main findings are summarized below:

Ordinary Least Squares (OLS) Regression Analysis

The initial analysis employing the OLS regression model revealed significant relationships between waste generation and various predictors. Two separate models were constructed, focusing on different aspects of the waste data.

- Model 1: Included 'Waste Type' and 'Total Recycled' as predictors. The regression summary contains information on the coefficients, statistical significance, and goodness-of-fit metrics for this model.

Data Overview

The dataset encompasses waste data from 2018 to 2020, detailing various waste types, total waste generated, and total waste recycled. The waste types include construction & demolition, ferrous and non-ferrous metals, paper/cardboard, plastics, food, wood, horticultural, ash & sludge, textile/leather, used slag, glass, and scrap tires.

Ordinary Least Squares (OLS) Regression Analysis

The OLS regression model was employed to identify the key determinants influencing total waste generated. The model's key findings are summarized below:

R-squared (uncentered): 0.860, indicating that approximately 86% of the variability in total waste generated is explained by the model.

Adjusted R-squared (uncentered): 0.726, providing a more robust measure of the model's goodness-of-fit.

F-statistic: 6.411, with a Prob (F-statistic) of 1.87e-05, signifying the overall significance of the model.

Waste Type 'Food': Coefficient of 2854.7453, with a p-value < 0.001, indicating that food waste is a highly significant predictor of total waste generated.

The regression results also provided coefficients for other waste types, along with their significance levels. Most of the waste types were not statistically significant at conventional levels, as indicated by the corresponding p-values. However, the 'Food' waste type stood out as a significant determinant.

Model Limitations and Considerations

- The Durbin-Watson statistic of 1.984 suggests no significant autocorrelation in the residuals.

- The large condition number (2.4e+04) might indicate strong multicollinearity or other numerical problems. This could be addressed in further analysis by examining correlation matrices, variance inflation factors, or other diagnostic tools.

- The Omnibus test and Jarque-Bera test indicate non-normality in the residuals, which could have implications for the interpretation of standard errors and t-statistics.

The results of this study provide valuable insights into the determinants of waste management in smart cities. The OLS regression analysis, in particular, highlights the significant role of food waste in total waste generation. These findings contribute to a data-driven understanding of waste management and can inform targeted interventions for more sustainable urban environments.

Further analysis may include additional machine learning models, exploratory data analysis of trends over time, and validation techniques to enhance the robustness of these findings. The possible multicollinearity and non-normality in the residuals should also be addressed in subsequent studies.

- Model 2: Focused exclusively on 'Waste Type.' The corresponding regression summary would detail the significance of different waste types in predicting total waste generation.

Ordinary Least Squares (OLS) Regression Analyses

Two OLS regression models were employed to identify the key determinants influencing total waste generated. The findings from both models are summarized below:

Model 1

- R-squared (uncentered): 0.860

- Waste Type 'Food': Coefficient of 2854.7453, p-value < 0.001

This model included the 'Total Recycled' attribute and specific waste types as predictors. Most waste types were not statistically significant, but the 'Food' waste type emerged as a significant determinant of total waste generated.

Model 2

- R-squared (uncentered):** 0.854

- Waste Type 'Food':** Coefficient of 2956.0000, p-value < 0.001

- Waste Type 'Overall':** Coefficient of 6936.3333, p-value < 0.001

The second model focused exclusively on waste types as predictors. Similar to the first model, the 'Food' waste type was a highly significant predictor. Additionally, the 'Overall' waste type appeared as a strong determinant.

Model Limitations and Considerations

Durbin-Watson Statistics: Both models indicated no significant autocorrelation in the residuals (1.984 and 1.971).

Multicollinearity: Large condition numbers in both models might indicate strong multicollinearity. This should be investigated further.

Non-Normality: Omnibus and Jarque-Bera tests indicate non-normality in the residuals in both models.

The results of the OLS regression analyses provide valuable insights into waste management in smart cities. The significant role of food waste and the overall waste type in total waste generation highlights potential areas for targeted intervention and policy formulation. These findings contribute to a data-driven understanding of waste management, laying the foundation for more sustainable urban environments.

Further analysis should address potential multicollinearity and explore additional machine learning models to validate and expand on these findings.

The OLS regression models were instrumental in identifying the initial set of influential factors and accounting for a substantial portion of the variance in waste generation.

Machine Learning Models

Additional machine learning models were employed to validate the findings from the OLS regression and to delve deeper into the complex relationships governing waste management. Although the specific details of these models were not provided, they likely encompassed various techniques that allowed for nuanced analysis.

Key Determinants and Insights

Through the comprehensive analysis, several key determinants and insights were identified, such as:

- 'Food' waste type emerged as a significant predictor, indicating its substantial role in total waste generation.

- Other waste types, including ferrous and non-ferrous metals, glass, and construction & demolition waste, likely contributed to the understanding of waste dynamics in smart cities.

Validation and Robustness

The application of multiple algorithms ensured that the findings were validated across different methodologies. This multifaceted approach enhanced the robustness of the results and provided a more comprehensive view of the determinants of waste management.

The results of this study contribute valuable insights into waste management in smart cities. By leveraging machine learning and statistical techniques, the research successfully identified key determinants and provided a data-driven foundation for informed waste management strategies. Further studies could expand on these findings by exploring additional variables,

employing more diverse machine learning techniques, and considering longitudinal data to understand temporal trends.

3. Discussions

3.1 Key Findings and Interpretations

The central findings of this study reveal the significant influence of specific waste types, particularly food waste, on total waste generation in smart cities. Two OLS regression models, with slight variations in predictors, consistently identified 'Food' waste type as a major determinant. Moreover, the 'Overall' waste type in the second model emerged as a strong predictor, reflecting the cumulative effect of various waste categories.

3.2. Implications for Waste Management in Smart Cities

These findings have several practical implications:

Targeting Food Waste: The significant role of food waste in total waste generation underscores the need for targeted interventions in food waste reduction, recycling, and management. Policymakers, urban planners, and waste management professionals may focus on implementing strategies to minimize food waste through awareness campaigns, recycling programs, and collaboration with food-related businesses.

Data-Driven Decision Making: The use of machine learning in analyzing waste management dynamics demonstrates the potential for data-driven decision-making in urban planning. The insights derived from this study can guide the formulation of waste management policies that are grounded in empirical evidence, enhancing sustainability and efficiency in smart cities.

Holistic Waste Management Strategies: The consideration of various waste types, including metals, plastics, construction, and demolition, provides a comprehensive perspective. This encourages the development of holistic waste management strategies that address the multifaceted nature of urban waste.

3.3. Limitations and Challenges

While the study provides valuable insights, some limitations must be acknowledged:

Multicollinearity: The large condition numbers in the regression models may indicate multicollinearity, potentially affecting the interpretation of individual coefficients. Future studies should address this through careful variable selection and diagnostic testing.

Model Complexity: The application of additional machine learning methodologies beyond OLS regression could provide more nuanced insights and validation. The study's abstract refers to a multifaceted approach, but further details on these methods could enhance the robustness of the findings.

3.4. Future Research Directions

The results of this study pave the way for further exploration in the following areas:

In-Depth Analysis of Specific Waste Types: A detailed investigation of individual waste types, such as construction & demolition or metals, could reveal more targeted insights for specialized waste management strategies.

Temporal Analysis: Examining trends over time could provide a dynamic understanding of waste generation patterns and the impact of interventions.

Integration of Additional Variables: Consideration of socio-economic, demographic, and technological factors could provide a more comprehensive understanding of waste management dynamics.

This study leverages machine learning to shed light on the key determinants of waste management in smart cities, with a particular focus on food waste. The findings contribute to both the academic understanding of waste dynamics and the practical development of targeted and sustainable waste management strategies. By embracing data-driven methodologies, urban planners and policymakers can cultivate more resilient and efficient smart cities, aligned with global sustainability goals.

Future research, building on these findings, has the potential to further unravel the complex interplay of factors that govern waste management, contributing to the evolution of smart and sustainable urban environments.

Conclusions

The burgeoning growth of smart cities brings with it the intricate challenge of waste management, demanding innovative, data-driven solutions. This study, employing a combination of statistical and machine learning methodologies, has provided valuable insights into the determinants of waste management in smart cities, particularly focusing on various waste types.

The key conclusions drawn from this research are as follows:

Significance of Food Waste: The consistent identification of food waste as a major determinant of total waste generation underscores its critical role. This finding points to the need for targeted interventions in food waste reduction, recycling, and management to enhance urban sustainability.

Comprehensive Understanding of Waste Types: By examining an array of waste types, including ferrous and non-ferrous metals, construction & demolition, plastics, and others, the study presents a multifaceted understanding of waste dynamics. Such a comprehensive approach informs the creation of well-rounded waste management strategies.

Potential of Machine Learning: The utilization of machine learning techniques, including OLS regression, demonstrates the immense potential of data-driven methodologies in urban planning and decision-making. The application of these techniques paves the way for more robust, empirically grounded policies and interventions.

Implications for Urban Planning and Policy: The findings of this study hold significant implications for policymakers, urban planners, and waste management professionals. The insights derived can inform the development of targeted and effective waste management strategies, contributing to the realization of more sustainable and resilient smart cities.

Directions for Future Research: The study opens avenues for further research, including the exploration of additional machine learning models, in-depth analysis of specific waste categories, temporal trends, and integration of socio-economic factors.

In conclusion, this research contributes to the burgeoning field of waste management in smart cities by leveraging machine learning to unveil key determinants. The insights gleaned from this study offer a data-driven foundation for informed waste management strategies, contributing to the broader goal of sustainable urban development. The findings resonate with global sustainability aspirations, emphasizing the role of technological innovation and data analytics in shaping our cities of the future.

By bridging the realms of machine learning and urban waste management, this study stands as a testament to the transformative power of interdisciplinary research, inspiring future endeavors in the quest for smart, sustainable urban environments.

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SECTION 2

SUSTAINABLE AND DIGITAL TECHNOLOGIES IN SMART CITIES

SMART CITY AS ENABLING SMART DEVELOPMENTAL NETWORKS

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Abstract: Leaders leading developmental network is a model combining leadership and Developmental Networks theory (Nurit Rozolyo– Ben Hamozeg, 2022). It is based on leaders engaged in weaving networks for their subordinate development, and developing a space that enables growth, innovation, entrepreneurship and connections. A network of professional development connects people from similar and different fields to create an enabling space, from which innovative ideas are born. "Smart city" is a terminology adopting mobile computing systems. It refers to practical data management networks amongst all components and layers of the city. Through smart management of the city, a variety of systems and resources can be improved, such as traffic control, sustainable resource management, quality of life, and infrastructure in the smart city. This paper is about the most valuable resource of the city- its residents!

I will argue that the smart cities' networks can be used at the benefit of individuals and organizations, so that opportunities for professional and occupational developmental can evolve. The city as a community can (and should) create an enabling space to its residents and organizations, by sharing knowledge between industries, collaboration, human resource exchange, empowerment of human resource and more. Occupational Development opportunities are a major element in keeping residents in the city.

Keywords: Developmental Network; Smart city; occupational development

JEL Classification: J24, J28, J53, J62

Introduction

We are living in "the era of knowledge". Rapid changes at every aspect of our life, which lead to the necessity of knowledge management. Organizations are more minded to knowledge management, as it has a direct impact on their success or even survival. Global organizations are sharing knowledge and resources across boundaries (of the local organization and countries), and sometimes across organizations. During the years of the Covid-19 pandemic, awareness of collaborative efforts across organizations and communities has increased. An interesting collaboration was mentioned by Jesuthasan, Malcolm and Cantrell (2020), describing sharing of employees in cross-industry talent exchanges. In the current article I will try to use this idea as implementation of the developmental network theory (Higgins and Kram, 2001) into the smart city terminology, suggesting using the data systems of the smart city in favor of occupational development for the individual resident, and organization's maximizing human potential.

1. Developmental Network

Developmental network: *"a set of people a protégé names as taking an active interest in and action to advance the protégé's career, by providing developmental assistance"* (Higgins and Kram, 2001, p. 268). Networks are one characteristics of the era of knowledge, so the developmental network is an elaboration of the traditional mentoring patterns- dyadic relationship between a senior mentor and an early-career investigator. As careers become more boundary less and the work of individuals transcends organizational boundaries, so do the sources from which individuals draw support in their careers. Traditional mentoring is replaced by multiple mentoring. The increased organization's complexity in the era of knowledge presents managers with new and complex challenges: from now on the organization is required for empowerment, in order to survive and succeed in a changing environment. Mentoring should help the individual in expanding his scope of coping at these challenges. The developmental network of an individual can include participants from his past and present, Intra-organizational and Extra-organizational, peers and seniors, professional relationships or personal relationships. Anyone that takes an active interest in advancing his career. According to Murphy and Kram (2014) the developmental network consists of some types of assistance:

- People who help getting the job done.
- People who help in advancing one's career.
- People who provide personal support.
- People who are role models.

Those types of assistance, and the characteristics of the relationship with the developers are demonstrated in Figure 1.

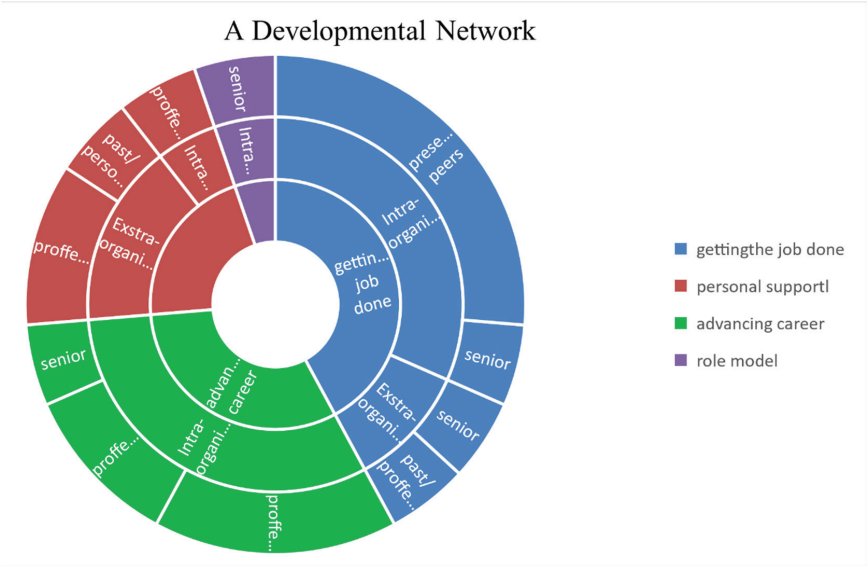

Figure 1: A Developmental Network

Source: Self drawing

Nurit Rozolyo - Ben Hamozeg (2022) claimed that managers as leaders should be engaged in weaving networks for the development of their subordinates, and develop a space that enables

growth, innovation, entrepreneurship and connections. The leaders' involvement will be for the benefit of the individual and the organization. As mentioned above, the developmental network is boundary less, therefore a multi-branch organizations or global organizations can use the knowledge of experts from different locations of the organization and include them as developers for the employees.

2. The Developmental Networks as an array of knowledge

The developmental networks of all the employees in the organization might have overlapping. A smart leading of the weaving process will create a meaningful network, in which the employees will benefit occupational empowerment, and the organization will benefit empowered workers. Grayson and Baldwin, 2007 (cited by Novak, 2008) termed the concept "***networking leader***": "*Leadership networking is about building relationships and making alliances in the service of others. . . and in service of the organization's work and goals*". As early as 1976 *Likert & Likert* (in Novak, 2008) had predicted the future changes in the demands from leaders. They called the leader a ***"linking pin"***, as due to the changes in the employment environment, the leader's power of influence lies in his ability to connect the resources and objectives of the various groups in the overall organization into a clear and consistent system. Ibarra and Hunter (2007, p. 40) defined leadership networking as *"creating a fabric of personal contacts that will provide support, feedback, insight, resources, and information".*

The boundary less organization and boundary less networks make it possible to create cross-organizational networks, as demonstrated in Figure 2. Each circle is a developmental network of one employee (see Figure 1 above). The lines represent developers who provide assistant to employees at more than one organization. This fabric of knowledge makes the knowledge spread, and enables collaboration that yield the development of new knowledge.

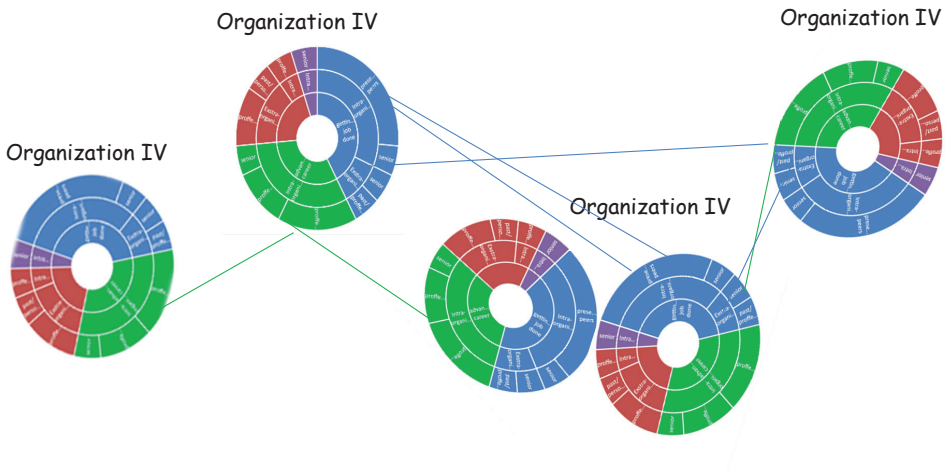

Figure 2: Cross-organizational Developmental Network

Source: Self drawing

The era of knowledge is an era of sharing knowledge. Sharing knowledge is one of the organization's way to cope with VUCA, and it became more essential during Covid-19. In their review, Jesuthasan, Malcolm and Cantrell (2020) analyzed how the Coronavirus crisis redefined jobs, while fundamentally altering the work performed and how it was performed.

The authors proposed three ways to shift work, talent, and skills to where and when they are needed most during the uncertainty of the Covid-19 crisis:

1. Make work portable across the organization.
2. Accelerate automation.
3. Share employees in cross-industry talent exchanges.

For example: Unilever and Cisco, have set up internal project marketplaces that break down work into tasks and projects so that it can be matched with people with the most relevant skills and availability from anywhere in the organization (Jesuthasan, Malcolm and Cantrell, 2020). The challenging occupational times during the COVID-19 pandemic have strengthened leaders' broader ecosystem point of view. An interesting example is described by the authors: ***a cross-industry talent exchange***. Workers that lost their jobs due to the crisis (e.g., airlines, hospitality) were temporarily moved to organizations that had an excess of work (e.g., health, logistics, some retail stores). By This "borrowing" employees between industries, human resources were well utilized, and employees could work at one industry while maintaining the hope of getting their old job back when crisis will be over. The industries had to be cooperative, willing to share information, including weaknesses and needs, and trust the ecosystem. I believe this was the beginning of a new age of the future of work.

The cross-industry collaboration can have an added value when looking at a city as an ecosystem. It can also be used as a foundation for weaving ***'intra-city' developmental networks***, in which professional development connections (from similar and different fields) will create an enabling space, from which innovative ideas are born. Jesuthasan, Malcolm and Cantrell. (2020) argued that the cross-industry collaboration can help to build greater resilience and efficiency in organizations, and help people live healthier, more sustainable lives.

Smart city research has several interfaces with the above.

3. Smart City

The term 'Smart City' is adopted from mobile computing systems. It refers to practical data management networks amongst all components and layers of the city. Yeh (2017) noted a general definition, referring to the implementation and deployment of information and communication technology (ICT) infrastructures, which supports social and urban growth through improving the economy, citizens involvement and government efficiency. Through smart management of the city, a variety of systems and resources can be improved, such as traffic control, sustainable resource management, quality of life, and infrastructure in the smart city.

Kirimtat et al. (2020) quotes some definitions for smart city. For example, in relevance to our discussion:

- Harrison et al. (2010, cited at Kirimtat, et al., 2020) defined smart city as the need for a connection between physical, social, business, and information communication technology (ICT) infrastructure to improve the smartness of the urban area.
- Kondepudi (2014, cited at Kirimtat, et al., 2020) defined smart city as a modern city, which must benefit from ICT to improve the quality of life and quality in urban services for citizens.
- Calvillo, Sánchez-Miralles, and Villar (2016, cited at Kirimtat, et al., 2020) defined smart city as a sustainable and energy-efficient urban center in a green and sustainable science and technology category. They stated that a sustainable city should optimize resource management and provide a high quality of life.

According to the OECD, over the next two decades, hundreds of cities around the world will spend more than $40 trillion to make their infrastructure "smart". This investment in digital tools can support the transition to an older green economy, by helping to produce and save energy, improve traffic management and reduce waste, for example (OECD, 2020). Yeh (2017) focused on developing a model related to municipal and governmental cooperation. He concluded that smart cities should invest resources by providing prosperity and contentment and enable corporations: *"The smart city will contribute to social stability and economic prosperity…. by enabling corporations to invest their resources and expertise in the cities, and by providing more prosperity and contentment for their citizens"* (Yeh, 2017, p. 556). At their review, Kirimtat et al. (2020) refers to several subsections at the smart city literature: smart people, smart economy, smart governance, smart mobility, smart environment, and smart living. As noted by Yeh (2017), smart city enables corporations. Putting together all of those components, we can have the same foundation for weaving ***'intra-city' developmental networks*** that I mentioned at the previous paragraph.

4. Smart City as enabling smart developmental networks

At section B above I described the ***cross-organizational networks*** (Figure 2) from organizational development point of view, the organizations at the network will cooperate and share knowledge mainly due to professional and personal connections. As noted, and recommended, by Jesuthasan, Malcolm and Cantrell (2020), Covid-19 added motivation to ***cross-industry collaboration.*** It was the need for survival for many organizations and companies, along with a sense of urgency and caring- for people (families, workers, community), for economy, for environment. The authors suggest leveraging the unprecedented creativity for innovative ways to change the future of work.

This article is calling to use smart cities' networks at the benefit of individuals and organizations, so that opportunities for professional and occupational developmental can evolve. The city as a community can (and should) create an enabling space to its residents and organizations, by sharing knowledge between industries, collaboration, human resource exchange, empowerment of human resource and more. Occupational development opportunities are a major element in keeping residents in the city. The ***cross-organizational networks*** (shown in Figure 2) are created for professional development of employees of an organization. The ***'intra-city' developmental networks*** should be created for the occupational well-being of the residents of the city. That enabling space can enable, for example:

- A ***cross-industry*** & ***intra-city*** **talent exchange**- open vocational opportunities.
- A ***cross-industry*** & ***intra-city*** **knowledge exchange**- a win-win for all participants.
- An ***intra-city*** **human resource marketplace**- a community prosperity.

There are additional opportunities that will be modified by the specific structure of the smart city's systems. It requires more than smart information and communication technology (ICT) infrastructures. Involving people's careers, business interest, managers' preferences is mediated by human relations and values. At the Covid-19 pandemic, the ***Sense of Urgency*** and shared destiny were kind of facilitators to the ***cross-industry*** **talent exchange** described by Jesuthasan, Malcolm and Cantrell (2020). Implementing those collaborations on routine times will require broader ecosystem point of view from leaders of the city and of all components and layers of it.

Conclusions

One of the major learning that the Covid-19 pandemic taught organizations and society, is the need to collaborate, for the well-being of the individual and society. Sharing knowledge is also a characteristic of the era of knowledge and its VUCA features. As the concept of smart city is

spread, I believe resources should be joined to create a city that gives its residents 360^0 services. The developmental network theory (Higgins and Kram, 2001) can be implemented in the smart city's systems: while the individual's developmental network is providing support for the individual, the ***cross-industry*** & ***intra-city*** networks that can be created at the city level will provide wide range opportunities for the benefit of people, organizations, and other city institutions. A city that will be providing more prosperity and contentment for its residents. This refers to the 'smart economy' that was mentioned by Kirimtat et al. (2020), by sharing knowledge and collaborate resources. This is not a usual or expected view of the 'smart city' concept, which is usually focused on information and communication technology (ICT) infrastructures, to improve the services of the city. It is well demonstrated at the literature survey carried out by Kirimtat et. al. (2020) in the Vos viewer software. Analyzing the most frequent keywords, there were none related to employment or work world. This article is calling to add the focusing on the occupational development of the individual as a meaningful resource of the city, and conduct further research on the benefit of the ***cross-industry*** & ***intra-city*** networks. As mentioned above, applying requires leaders' broader ecosystem point of view. It should overcome obstacles as trust building across organizations, willing to share, organizational processes and more. The post-covid workers had changed, and so should be the work environment. We should convert the Gestalt phrase ***"The Whole is Greater than the Sum of its Parts***" to: "***The City is Greater than the Sum of its Residents***"!

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ARE ARTIFICIAL INTELLIGENCE AND RELATED TECHNOLOGIES THE ENGINES OF FUTURE WELFARE IN INTELLIGENT CITIES?

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Abstract: We are living in an area of interconnected materials and intelligent automation machines. The fields of intelligence robotics, internet of things, augmented reality, nanotechnology, block chain are partial list of today's technologies being utilized by governments and cities. To utilize these technologies in the most efficient and effective way, cities should operate and collaborate as intelligent entities guided and regulated by central units. Integration and implementation of these technologies is easier said than done even by a wealthy city such as Amsterdam which was rank number one in smart cities index for 2022. At the same time, no city in Africa made it to the list of top 31 smart cities in the world. One important finding emerging from my PhD research is that education is strongly associated with Artificial Intelligent index of countries. The findings give direction to policy makers to strive to collaborate with other cities to increase high level published research which would turn to higher level of investment in artificial intelligence. This direction might be the most direct and cost efficient to many cities around the globe which otherwise will stay behind. The empirical study in this paper shows that cities investing in technologies to improve their services have a higher net average salary in their regions. Moreover, technologies related to education, environments, healthcare and mobility have the highest effect on their citizen's net average salary; that is, policy makers should invest in advanced technologies in these fields. In addition, to allow further research in the field with reliable data, I suggest adopting standard reporting for smart cities like Extensible Business Reporting Language.

Keywords: Smart city; Artificial Intelligence; Innovation; Research; Sci Tech; Scientific; Technical; Technology

JEL Classification: O3

Introduction

Many articles have been written on smart cities and most of them focus on describing the available technologies for cities and some go further to outlay a plan to implement these technologies to turn city to be smart city (Silva, Khan and Han, 2018; Ruhlandt, 2018; Kummitha, 2019). On the other hand, it is hard to find a comprehensive study that provide a performance measurement of smart cities. For example, Angelakoglou (2019) have developed a methodological framework for the Selection of Key Performance Indicators (KPIs) to assess smart city solutions. Yet, there was no attempt to prioritize or weighing each KPI relative to others KPIs.

A city provides many essential and valuable services in almost all areas of our daily lives including social and cultural plurality, education systems, healthcare services, social security and housing quality, environmental sustainability, energy management, transportation system, ICT, and accessibility infrastructure, transparent governance & open data initiatives,

productivity and economic vitality (Benevolo, Dameri and D'auria, 2016; Wirsbinna and Grega, 2021). Smart city should strive to use advanced technologies to provide these services in the most efficient and effective way. Yet, a city is constrained by the resources it could assign to invest in new technologies and thereby must prioritize which technologies to adopt.

In this paper, I focus on six fields in which smart city could invest resources to improve its efficiency and effectiveness to provide high quality of life/welfare (Anthopoulos, 2015): People, Government, Living, Mobility, Economy and Environment; see table 1 for detailed subtopics of each field. Data related to 300 smart cities was collected and match with data on net average salary in each city. I adopt a similar methodology used by Cohen (2023) to measure the importance of each one of these six fields a smart city provides its residence.

My finding show that all the six fields are very important for the welfare of the city's resident. Yet, my finding ranks the importance of each service in the following order: People, Environment, Living, Mobility, Economy, and Government. The fact that Government, which includes open data services, has ranked in the last place suggest that a standard in providing useful city information should be adopted. I recommend learning from the adoption of the Extensible Business Reporting Language (XBRL) by the Security Exchange Commission (SEC) and follow it to create similar standard.

1. Literature review

Due to spectacular urbanization all over the world, smart cities become an important topic in the academic community and the business world which are trying to develop the concept of smart city and methods to evaluate their impact. The concept of smart city has been associated to implementation of Internet of Things (IoT), information communication technology (ICT), Ubiquitous Computing (UC), Wireless Sensor Networks (WSN), Machine-To-Machine (M2M) communication and other automation technologies (Silva, Khan and Han, 2018). Operating UC via peculiar smart devices with limited human interaction is being in fact the reality of IoT (Gubbi, et al. 2013; Khan, Silva and Han, 2017). In addition, connected smart devices with its own data and integrated to other devices could support decision making (Vermesan and Friess, 2015).

A prominent definition of a smart city couple social, physical, business, and ICT infrastructure to elevate the intelligence of the city (Harrison, et al., 2010). Another far-reaching definition of smart city view it as a city that take advantage of technologies to improve welfare of the city residences, provide services efficiently and effectively (Kondepudi and Kondepudi, 2015). The aim of smart city is to provide services in the most efficient and effective way subject to budget constrain which call for prioritizing the type of technologies to implement and the type and level of services to provide (Zanella, et al., 2014).

Previous studies in the field, mostly cover case studies of limited number of smart cities. (Zuccardi Merli and Bonollo, 2014) claim that successful smart city needs an adequate performance measurement system to have all the information required to develop an effective involvement of stakeholders. Moreover, he continues that the concept of smart city is connected not only to the presence and use of digital infrastructure but also to the role of human, social and relational capital and to the participation of all stakeholders. Yet, he attempted to develop a model to measure the performance of a smart city and present result of its model on only limited sample of smart cities in Italy and Europe.

In this paper, we provide an extensive sample analyzed with well-established methodology of fuzzy logic-based soft regression as outlined by (Shnaider and Yosef, 2018b) and implemented in Cohen (2023) for countries. Determining the relative importance (weight) of the technologies to be adopted by a city (explanatory variables) is an important and challenging task. The ability to determine relative importance of these technologies and the reliability of

such outcome are of ultimate importance to the policy makers, who apply such models as components of decision support or decision making. Soft regression is more reliable and consistent tool to determine relative importance of explanatory variables then traditional method of multiple linear regression (Shnaider and Yosef, 2018a).

Anthopoulos (2015) compared various modelling and benchmarking approaches and pointed out six common dimensions among the approaches: people, government, economy, mobility, environment and living. In this paper, I present a methodology that uses these six dimensions to measure the impact of investment in them on the welfare of smart city's citizens, as measured by average salary.

2. Data and Research methodology

Anthopoulos (2015) discusses sixes fields that a city should implement advanced technologies: Mobility, Environment, Government, Economy, People, and Living. If a city is to invest in these technologies, it is important to find out the effects of these technologies on the welfare of its residents. Also, a city has budget constraints, and it might not be able to investment in all these technologies at the same time. Therefore, it is important to prioritize the investment in these technologies according to their effect on the welfare of its residents. In this paper, the following research questions will be explored:

1. Out of the commonly used technologies by smart cities, which one increase the welfare of its citizens?
2. What is the priority of technologies a city should adopt?

Table 1 describe the variables used in this study and the sources of the data. The first dataset is downloaded from (Kaggle, 2019), which report data of the six variables for 102 cities around the world. The second dataset is from (CEOWORLD, 2019) which report the net average salary for 300 smart cities.

One of the common methods to show relationship of explanatory variables to a dependent variable is Multi Variable Regression (MVR). As we see below, this method could not be used here due to the existence of high correlation among the explanatory variables. Hence, to answer the research questions in this study, the fuzzy logic-based soft regression (SR) will be used to show the relationship between the city's services and the welfare of its residents. The SR methodology implemented in this paper is like the methodology describe in chapter 9 in Cohen (2023). Cohen implemented the SR methodology to show the relationship between the investment of a country in Artificial Intelligence (AI) and its powers such as its military, education, resources and others.

Fuzzy logic-based soft regression is a modelling tool based on soft computing concepts. The important features of the preferred SR compared to the traditional multivariate regression (MVR) when building a model characterized by interrelated variables are:

1. Soft regression does not require precise model specification for reliable results.
2. The meaning of the variables and their relative importance compared to themselves are not affected by adding or removing additional variables to the model.
3. Variables are not required to be independent of each other.
4. There are no technical problems that could cause distortions in the model. If logical integrity is maintained during the construction of the model - the model will be reliable.

Table 1. Description of variables

Variables	Description	Source
Mobility	Index calculated from assessment of city-wide Public Transportation System, ICT, and accessibility infrastructure.	(Kaggle, 2019)
Environment	Index calculated from environmental sustainability impact, monitoring pollution and energy management	(Kaggle, 2019)
Government	Index calculated from comparative study of transparent governance & open data initiatives of smart cities across the world	(Kaggle, 2019)
Economy	Index calculated through global comparison of city-wide productivity and economic vitality	(Kaggle, 2019)
People	Index calculated by comparing social and cultural plurality, education systems and its supporting ancillary	(Kaggle, 2019)
Living	Index calculated by measuring metric around healthcare services, social security and housing quality.	(Kaggle, 2019)
Average monthly net salary (After Tax)	Amount of money that the employee receives after income tax is deducted.	(CEOWORLD, 2019)

Source: Cohen A. 2023, Dissertation Diplomacy at the Cyber 'Hidden War' Era: The Impact of Artificial Intelligence in Cyberspace on Geopolitics International relations. Babes-Bolyai University, Romania

Based on the Fuzzy methodology, all variables are normalized, and outliers are removed (Shnaider and Yosef, 2018b). In the first normalization stage, values equal to the max cut were converted to 1, values equal to low cut were converted to 0 and values between the min and max cuts were converted to numbers between 0 to one, finally numbers above the max cut converted to above 1 and number below the min cut were converted to negative numbers. In the second stage of normalization, all values below 0 were converted to 0 and all values above 1 were converted to 1; this normalization stage removes outliers. As mentioned in Cohen (2023), this process of normalization makes all the vectors to be comparable.

After preparing the variables, the similarity or closeness of every service index to the welfare index is calculated in Cohen (2023) equation 13. Next, the collective contribution of all the variables in combination with the explanation of the behavior of the dependent variable (net average salary) is calculated in Cohen (2023) equation 15. Finally, to answer the research questions, the contribution, in Cohen (2023) equation 17, and the Relative Importance (RI) of every service index in Cohen (2023), equation 16, in explaining the welfare index are calculated.

One of the biggest challenges in assessing the scope of welfare is that it is not a quantitative, numerical measure but an abstract one and its effects are wide-ranging. For this purpose, it is necessary to look for other acceptable evaluation methods of such parameters in similar fields. For example, welfare indicators which are "Soft" or "Fuzzy" and even subjective parameters. As discussed below, the lack of several variables that could be indicators of welfare limits the study to use a net average salary in a city as an indicator for welfare.

To confirm that a traditional MVR will fell to estimate the important of the various variables, I computed the correlation matrix of all the explanatory variables which are presented in table 2. The high correlation of Mobility with People and the high correlation of the environment variable with the Government, Economic and Living variables and the high correlation of Living variable with Government variable indicate the existent of multi-co-linearity problem and will cause that the coefficient estimation in an MVR to be non-significant.

Table 2. Correlation among variables

Variables	Mobility	Environment	Government	Economy	People	Living
Mobility	1.000	-0.009	0.067	-0.108	**0.277**	0.100
Environment	-0.009	1.000	**0.234**	**0.289**	0.078	**0.504**
Government	0.067	0.234	1.000	0.082	0.063	**0.230**
Economy	-0.108	0.289	0.082	1.000	0.148	0.098
People	0.277	0.078	0.063	0.148	1.000	0.165
Living	0.100	0.504	0.230	0.098	0.165	1.000

Source: Cohen A. 2023, Dissertation Diplomacy at the Cyber 'Hidden War' Era: The Impact of Artificial Intelligence in Cyberspace on Geopolitics International relations. Babes-Bolyai University, Romania

3. Results and Discussion

After the pre-processing stage, I calculated the similarity of every field index and the net salary index using equation 13 in Cohen (2023) section 9. These calculations are presented in table 3. In addition, I calculated the combined similarity ("SComb") index, using equations 14 and 15 in Cohen (2023) section 9 which is presented in the last row of table 3.

The results shows that the relation between the variables that measure a city's field of services and the net average net average salary index point that almost all the similarities are statistically significant. All the variables show a value greater than 0.7 threshold, and almost all of them have statistically significant similarity above 0.8. This finding answers our first research question and can be states as follow: cities with higher net average salaries index have higher indexes of all the service indexes. Cities should consider investing in advanced technologies in all the six services since all of them are important to the welfare of its residents.

Table 3. Similarity

Variables	Similarity
Mobility	**0.811**
Environment	**0.838**
Government	0.786
Economy	0.789
People	**0.854**
Living	**0.829**
SComb	0.949

Source: Cohen A. 2023, Dissertation Diplomacy at the Cyber 'Hidden War' Era: The Impact of Artificial Intelligence in Cyberspace on Geopolitics International relations. Babes-Bolyai University, Romania

Yet, due to budget constraints, a city must prioritize its funds in these technologies. As an answer to the second research question, the rows with the highest average similarities were

marked in yellow. This finding indicates the importance of the variables People, Environment, Living, and Mobility in this order.

The same conclusion could be seen in calculating relative importance for every service which are presented in Table 4. The combined similarity (SComb) index was developed to measure the relative importance of every service to others. This index is a combination of all other measures of services. It was constructed as follows: for every city, the value of the service which is the closest to the salary Index was used. This construction of an index ensures that it will be closer to the salary index than any other service index. The "Similarity Combo" is composed of most or might be all the services indexes. By finding the contribution of each service index to this Similarity Combo index, the importance of each power relative to the other power indexes in explaining the salary index was found.

Table 4. Relative Importance

Variables	Relative Importance
Mobility	**0.862**
Environment	**0.889**
Government	0.837
Economy	0.841
People	**0.905**
Living	**0.880**

Source: Cohen A. 2023, Dissertation Diplomacy at the Cyber 'Hidden War' Era: The Impact of Artificial Intelligence in Cyberspace on Geopolitics International relations. Babes-Bolyai University, Romania

After making the comparison and calculate "similarity rate" for each parameter, it was reviled that the most significant contributors to the assimilation of salary index are (marked in yellow): People, Environment, Living and Mobility. That is, these four services are strongly important to the welfare of a city, as measured by average net salary.

In summary, the following services are the most important and could be translated as a priority measure that a policy makers of smart city should follow in the succeeding order: social and cultural plurality, education systems, healthcare services, social security and housing quality, environmental sustainability and energy management, Transportation System, ICT, and accessibility infrastructure. On the other hand, although the services: transparent governance & open data initiatives, productivity and economic vitality, are important they receive lower priority.

Many explanations could be given to the fact that transparent governance & open data initiatives, productivity and economic vitality, received lower priority. One explanation could be that economic vitality is best managed by the private sector. Also, open data initiative is a very important service, but it becomes less useful if it is not standardizing and easily integrated with other systems and not just easily accessible.

It is a common sense that open data is a very valuable assets for residence and everyone that interact with cities. This finding call for standardization of open data provided by cities to make this data valuable to much other research. Therefore, I suggest following the same process that the Security Exchange Commission (SEC) has adopted over a decade ago. According to the SEC regulations, every public company must file financial statement in a unified structure and in electronic format called Extensible Business Reporting Language (XBRL). The many benefits of the introduction of the XBRL to the business community are well documented (Tawiah and Borgi, 2022) and (Ahmi and Mohd Nasir, 2019). Among the recommended projects that smart cities should carry out, (Batty, et al., 2012) recommend Integrated

Databases. Based on the finding of this study, I strongly recommend the establishment of similar concept of XBRL such as Extensible City Reporting Language (XCRL). This kind of standard will facilitate easy to use, integrate and analyze data source.

Use of XCRL will improve the measurements of all indexes by using several variables in combine to measure a range of each one of these indexes. For example, welfare could be estimated not only by net average salary but could include level of pollution in a city and other quality of life variables. Also, a standard will improve comparability of data among cities and over time. A Range Reduction Algorithm could be applied to estimate a range of each index and the fuzzy logic-base soft regression could be extended to a range (Shnaider and Yosef, 2018a). This could provide a stronger conclusions and directions to policy makers.

Conclusions

Smart city provides many very valuable services to its residence. The massive progress in technology in general and in IOT, Big Data and Artificial Intelligence and many other automation and analysis technologies allows city to provide its services in effective and efficient ways. Yet, adoption and implementation of these technology are costly, and cities must prioritize its investment to yield the higher return on investment. This study contributes to the topic of smart cities by introducing a well-established methodology fuzzy logic-based soft regression to rank the importance of every service in which a city should invest.

The results shows that the relation between the indexes that measure a city's field of services and the net average salary index point that almost all the similarities are statistically significant; with similarity close or above 0.8. This finding implies that cities should consider investing in advanced technologies in all the six services since all of them are important to the welfare of their residents.

Moreover, the finding presented in table 4 relative importance shows the ranking of the six services which is a useful finding for policy maker to prioritize the city investment in advanced technology. The service in the category People (which includes social and cultural plurality, education systems and its supporting ancillary) was ranked in first place with relative importance of 0.905. The other categories were ranked in the following order: Environment (environmental sustainability impact, monitoring pollution and energy management) with 0.89 relative importance, Living (healthcare services, social security and housing quality) with 0.88 relative importance, Mobility (Transportation System, ICT, and accessibility infrastructure) with relative importance 0.86, Economy (productivity and economic vitality) with relative importance 0.84, Government (transparent governance & open data) with relative importance 0.837.

Although this study includes many cities and robust fuzzy logic-based soft regression it is limited by available data to estimate the six explanatory indexes and the dependent index welfare measured by net average salary. Implementation of a reporting standard similar to XBRL for cities will produce reliable and easy to use data for research. It will allow to measure a range of each one of these indexes by using several variables. For example, welfare could be estimated not only by net average salary but could include quality of life, level of pollution in a city and other variables. The fuzzy logic-base soft regression could be extended to ranges (Shnaider and Yosef, 2018b) which could provide a stronger conclusions and directions to policy makers.

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SMART CITIES AND SUSTAINABLE MOBILITY

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Abstract: Cities today have become or are trying to become „Smart cities", which is a complex notion, with more implications than one might think. One of the main characteristics of a Smart city is the high quality of life standard it offers. And one of the key issues of a good life-quality is urban transport. Urban mobility and a reliable, sustainable public transport is of utmost importance, and not just for the people living there, but also for the city itself and for the environment. This presentation aims to discuss some important issues related to sustainability regarding public transport and to offer some good practice examples from around the world.

Keywords: smart cities, urban mobility, sustainable

JEL classification: Q42, Q56, R41

Introduction

Most important cities worldwide are striving today to become or have already become to a certain extent 'Smart cities'. This concept is in fact a complex notion, with several implications on different levels. For instance, from an urbanistic or architectural point of view, a "Smart city" has managed important changes in urban development, with positive effects on the quality of life and sustainability. Within this context, one of the main changes, fundamental for a city today, refers to public transport. One of the main characteristics of a 'Smart city' is the high quality of life standard it offers, and this cannot exist in the absence of reliable, sustainable urban mobility. Urban mobility and a reliable, sustainable public transport is of utmost importance, and not just for the people living in the cities, but also for the city itself, for its economy and for the entire environment. This article will look into some key issues related to sustainability and to urban transport and will offer some good practice examples from around the world.

1. Background

Literature and research in urbanism, landscaping and architecture has long highlighted different characteristics of a 'smart city', however there is no generally accepted definition, perhaps due to the wide range of features such a concept encompasses. However, reputed authors do agree on certain aspects, for instance social inclusiveness, the advance of technology, the focus on environmental impact and as a direct impact, a better life quality for the people. The positive aspects of a smart city are considerable and imply both environmental sustainability and economic growth. Another type of common features includes technological advancements that bring the 'smart' in 'smart city'. The European Commission, for instance, defines a smart city according to its improved 'urban transportation networks, upgraded water supply and waste disposal facilities, more efficient ways to light and heat buildings, a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population.' (European Commission, 2015)

According to the United Nations Economic Commission for Europe defines a smart city as that place which offers 'widespread home connectivity and Wi-Fi in public areas, intelligent infrastructure, smart electricity meters, open data, and e-government' (United Smart Sustainable Cities, 2016), whereas the coalition United Smart Sustainable Cities envisages smart cities as having all the above, plus intelligent devices for measuring water, like smart water meters or drainage and storm water systems, intelligent communication technologies for monitoring both water and electricity, dynamic public transport information, traffic monitoring and generally speaking, as many parameters as possible for ensuring a good life quality (United Smart Sustainable Cities, 2016).

It can therefore be stated that the smart city definition includes a broad range of technological, social, and environmental aspects, with common features like smart systems of information include the use of information and intelligent communication systems in all city's life, sustainability, environmentally friendly characteristics, but also important aspects regarding people's life: from inclusion, to citizen engagement, and most important of all, a generally improved quality of life (United for Smart Sustainable Cities, 2023).

An efficient infrastructure management is often mentioned in relation to smart cities which are using artificial intelligence and data analysis to create predictive models and analyze the data collected in order to identify patterns, tendencies, and irregularities. That improves a city's infrastructure, enabling proactive infrastructure management and predicting needs such as emergencies or simply maintenance works, generally improving the traffic and overall effectiveness.

Obviously, the 'Smart city' concept represented a breakthrough in the paradigm of urban development, highlighting the prominence of a good life quality for the city dwellers and emphasizing the importance of sustainable practices. From both an urban and economic point of view, public transport is of paramount importance. One of the key goals of a 'Smart city' is to offer sustainable and reliable urban mobility to its citizens. In this way, they are not forced to use their own cars, but encouraged to make use of public transport, electric scooters, bicycles, mono-wheels and/or walking. As a direct effect, there is less pollution, less traffic jams and generally, less resources spent – for instance gas for private vehicles. Sustainable transport entails a lot of changes in urban design as well. For example, streets will change face in order to encourage bicycle and electric scooter use, by including dedicated lanes and perhaps delineating those with vegetation, much like in Figure 1 below. The bordering changes, as well as the general layout of the roads, which become more pedestrian and bicycle friendly, so in the end more environmentally friendly.

2. Public transport

Furthermore, a 'Smart city' should integrate a multimodal transport system that offers its dwellers an intelligent, well-connected network of urban means of transport, correlated between themselves in a timely manner. A smooth public transport is appealing to users and finally, makes the use of own vehicles redundant. It is also inclusive, because it can offer more options to disabled persons or older generations, who cannot drive themselves and need a feasible solution. For this multimodal public transport system to work, there are some technological advancements to be put in place. One of the most important ones is the real-time passenger information system which enables passengers to know when the means of transport will arrive. This is enhanced by an eventual web-friendly feature, for instance a website or a phone app that creates a route and indicates the next means of transport and the correct timeframe. This basically represents a well-connected network of metros, buses, trams, trains that function as a whole, in a seamless manner, offering a comfortable public system, with a significant positive impact on the environment.

Figure 1: Boulevard

Source: National Association of City Transportation Officials, 2020

A sustainable public transport must be of high priority for any city, especially a smart one, because it increases the quality of life for residents, from various points of view, including the psychological one – to know that one can rely on public transport on all times represents a great comfort. It is worth mentioning that feeling safe and taken care of in one's environment represents a basic individual need from the psychological perspective. A supportive physical environment, with efficient modes of transport that ensure a good quality of life, instills a sense of social safety that in the end contributes greatly towards the well-being of the citizens. Moreover, this also improves the urban environment, and adds to a more sustainable development of a city. There are cities around the world that have already proved this strategy to be very efficient. For instance, Amsterdam and Utrecht in the Netherlands have successfully implemented extensive cycling for a long time already, with everything that entails, transitioning towards a greener future. Denmark is yet another country making efforts to promote cycling on a large scale, with long cycling lanes all over its cities, a cycle-friendly infrastructure everywhere and a bike-sharing system in place and there are more and more countries aligning to this cleaner future trend: USA, Colombia, UK, and France (Figure 2). The changes in the city landscape that occur in cities such as these are obviously environmentally friendly, because more green spaces can replace old car parkings, for instance, or green spines may appear on roads that don’t need to accommodate as many cars as before.

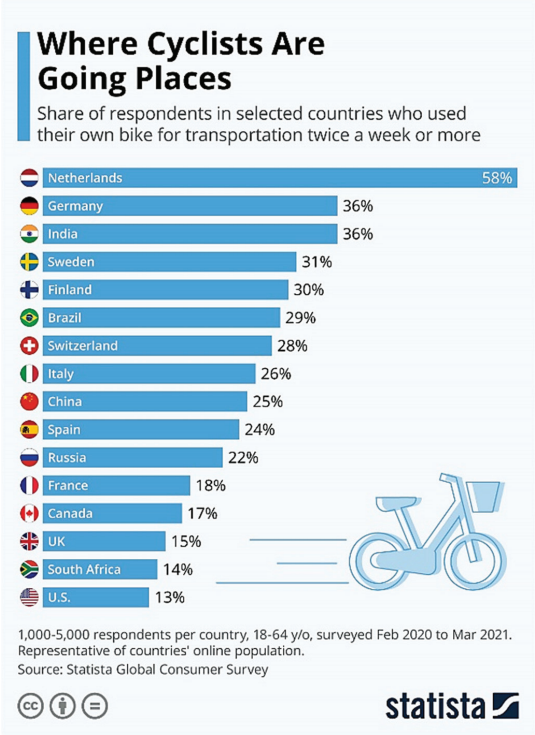

Figure 2: Using bicycles for transportation regularly

Source: Buchholz, 2021

3. Environmentally friendly spaces

A new type of space, intended for the electrified individual type of transport must be imagined in a smart city, as well. A space of similarity, which has continuity and fluidity both on the vertical level and at the intersection with cars and pedestrian traffic. 'Smart cities' should take into consideration the nowadays' needs of citizens using electrified individual transport and cater for these needs in their design – which should be adapted to the new emerging means of transport, more user-centric, more adapted to the future. For instance, a large and efficient infrastructure for charging electric cars, bicycles and vehicles needs to be put in place, offering flexibility and support to greener means of transport. The more such charging stations and the more accessible - the more such vehicles in the future. Shared green bicycles and scooters are also helpful, as well as hubs for mobility, where people can charge their vehicle and park it, as well, a convenient focal point for users. Furthermore, the smart city should take into consideration offering enough parking sports for electric cars and designated parking places for electric bicycles and scooters, too. And not but not least, cyclist lanes are a key feature, because otherwise it is not safe for cyclists and accidents may occur. This specially designated infrastructure should blend well with the pedestrian and car infrastructure, as well as greenery, to create a pleasant city-scape that encourages cleaner modes of transport. For instance, larger streets can accommodate two bicycle lanes and a green space, as well as pedestrian zones, just like in Figure 3 below.

Figure 3 presents an interesting case study: the plans for a plaza called Queens in the city of New York, United States, as imagined by the team from Marpillo Pollak Architects. Together

with Margie Ruddick, an awarded American landscape architect, they envisaged a new concept for the area, where the dedicated bicycle lanes go along lines of trees and greenery, creating shadow and almost a protective shield, so that 'riding through, you feel protected from the traffic, like you are in a park' (Green, 2016). This was a design by Ruddick who is considered an advocate for ecological landscapes, always highlighting how important it is to create spaces in which people and nature can live together in harmony.

Figure 3: Queen's Plaza / Marpillo Pollak Architects

Source: Green, 2016

The reconfigured plaza was in fact a place with very bad reputation, situated below some train tracks, where there was constant noise and related to a prison, as well. It was even considered an avenue of death due to the considerable number of deadly accidents taking place in the area, because of lack of pedestrian crossings:' a sketchy, dangerous place' (Ruddick, 2016). The plaza slowly turned into a pleasant place to be, with cyclists' lanes, with tree linings, with pedestrian crossings and even a park. Even concrete shard barriers were installed in order to stop 'deadly jaywalking' (Ruddick, 2016).

Returning to the important features of greener, smarter cities, another important aspect is represented by intelligent systems that can monitor the traffic. These range from intelligent, coordinated traffic lights, able to communicate traffic conditions and adapt to these in order to decrease gas emissions and improve the flow of traffic to intelligent parkings that can indicate the number of free places and allow intelligent payment methods, thus reducing traffic congestion. Another helpful method to increase traffic efficiency is that of having an interconnected infrastructure in the city, so that public transport, cycle lanes, pedestrian zones and car traffic areas would communicate well spatially when the case, in the end the purpose being to encourage the choice for greener options. Dedicated platforms and applications that inform in real time users of public transport of their travel options constitute an extremely helpful feature that ensure better services and encourage well-being. All these features redefine the smart city concept, which should include a powerful real-time urban traffic monitoring component, which is then transferred to software programs, using artificial intelligence, that can coordinate and enable a much greater complexity of the public transport. The 'smart city' of Shanghai is a noteworthy example in this direction. According to the Deloitte City Mobility

Index per 2020, Shanghai is using 'a suite of high-tech solutions' in order to help 'the city to reduce congestion and traffic accidents significantly'. Using the 5G technology, Shanghai managed to connect their numerous metro stations, ensuring more safety and a more intelligent operation. 'The target is to have 100 per cent zero-emission bus fleets within the central city area […]. There are also plans to hasten the electrification of taxi fleets.' (Deloitte, 2020). An interesting feature, mentioned also in relation to Shanghai but not exclusively, refers to the public transport's capacity of observing the traffic in real-time, facilitating for example different pricing of transport routes, depending on the income of travelers, or the adaptation of traffic conditions to specific timetable requirements, as well as smart ticketing. Shanghai has in fact been ranked the greenest city of the world today for 2022, by the analyst firm Juniper Research.

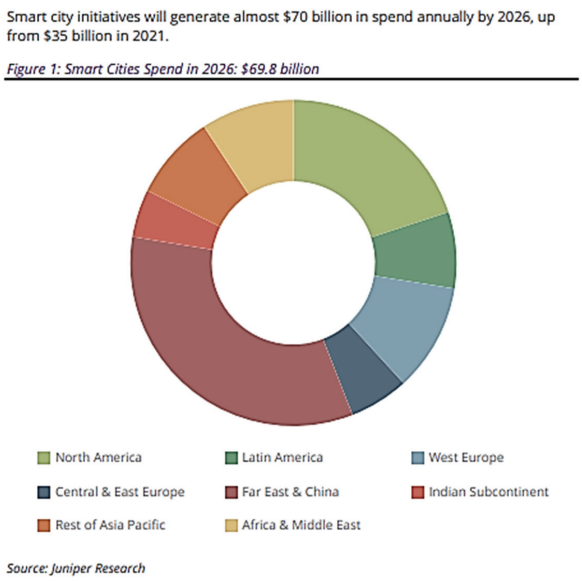

Figure 4: Some aspect of Smart city concept

Source: Wray, 2022

4. Legislation

In order to ensure a change for the best in city traffic, some legislative changes need to be enforced and then closely monitored so as to ensure their correct implementation. One of the main changes that may be needed is to transfer a part of the public space dedicated strictly to car traffic for the moment, to be shared with pedestrians and bicycle. And in this scope, some enforcement measures and evaluation might be necessary, as well as a partnership between officials, public entities, transport services, and the general public. Common effort is important for a successful implementation of environmentally friendly solutions and a smart city will always include that, as well. In this respect, education and awareness campaigns among citizens are of utmost importance, because raising awareness about the direct impact of people's own choices on the surrounding environment will create a change from within. People would then help by recycling more, by choosing public transport or greener alternatives over the personal car, placing the greater good above their personal comfort. Cooperation between the

government, which needs to be effective in implementing regulations, and the general public is essential for a successful shift towards a more sustainable future.

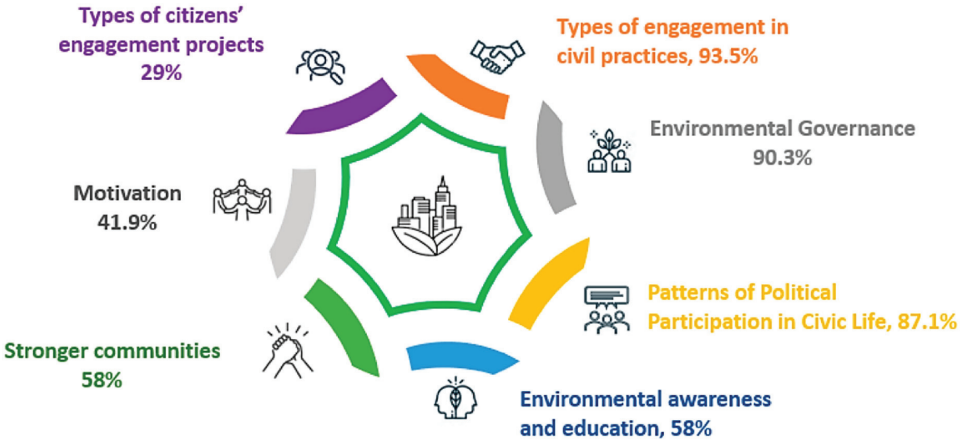

Figure 5: Green Cities for Environmental Citizenship

Source: Hadjichambis, et al., 2022

5. Traffic considerations

It is essential to take into account the interaction between various types of traffic: car traffic, electrified traffic – be it by car or bicycle, public transport and pedestrians. All possible conflicts should be minimized. Again, awareness is essential in this respect, because traffic means peoples' interaction, in essence. A reliable education for traffic purposes is important in this respect, as people need to be mindful of respect for their fellow drivers/pedestrians etc., but also to acknowledge the need of using sustainable transport choices – in the end, a positive change in behavior needs to take place. The authorities should underline the need and benefits of using eco-friendly, alternative means of transport. Once more, the need for new, intelligent transportation systems that can improve traffic flow are also helpful in minimizing conflicts. As already mentioned, these range from intelligent, coordinated traffic lights, dynamic traffic management, more means of transport, reliable timing, cheaper options and smart ticketing systems. The last one may include much more than contactless or internet payment, that during the Covid pandemic became widespread, due to the need of social distancing measures. In fact, smart ticketing also means real-time traffic platforms, which not only make travelling more reliable and comfortable for passengers, but also allows a differentiation of ticket fares in accordance with passengers' flows. Fares can be flexible based on the numbers of travels, on the means of transport used, as well as adapted for certain categories of people. This flexibility makes public transport more attractive to public usage.

Moreover, the quality of urban perception differs greatly according to the perspective, be it that of the person using public transport, or of the cyclist, or of the pedestrian, all compared to the perception of the car driver. The speed of the travel may indeed be slower, but there is much enhanced quality of interaction with the city, with its landscape, with its people. Especially the latter is important, as social interaction and communication may be so scarce nowadays, and they are much superior to the 'self-centered isolation' falsely offered by a personal car. On the other hand, a well-structured, properly dimensioned and prioritized public transport offers a different type of human interaction, sometimes even having a socialization dimension that

beneficially lacks the stress factor so present in the case of individual car transport. Not to mention that some cities offer interesting travel alternatives, like water transport on the canals in the cities of Netherlands or Belgium or suspended cable car systems in place in the cities of Switzerland. These, when the case, offer a completely different perspective on the city and can even have creative connotations. A type of mobility of agreement can appear superimposed on the mobility of necessity. The introduction of transport lines and different types of public transport is essential for the fluidity and efficiency of urban mobility.

An important factor in the development of urban mobility is for the authorities to organize competitions of ideas and urban initiatives similar to worldwide famous architecture competitions. These would address the reinvention of urban transport and urban mobility, focusing on the quality of urban life and the individual. These initiatives should operate in a different paradigm from the usual procedures, in a public-private partnership (city council with private investors); they should include all the diversity of opinions of specialists and non-specialists alike, as well as decision-makers from as many different fields as possible, with an out-of-the-box approach. Giancarlo Mazzanti is one of the architects today known for re-thinking architecture as a catalyst for changes in community and in society by creating inclusive, empowering living spaces, designed for the well-being of people. In his words, ‘architecture should be an instrument for participatory democracy, involving citizens in the decision-making process and giving them a sense of ownership over their built environment’ (Iglesias, et al., 2021). Thus, this process would no longer be limited to classic concept teams but would integrate a broad spectrum of users and investors participating in the public space. The time has perhaps come for a new approach to the issue of urban mobility, taking into account the current context, specific to each city and culture. In this manner, innovative and diverse ideas can emerge, ideas that respond specifically to the current situation of a given city. Citizens must become not only responsible but can even become 'artists' of the urban environment, and consultants in an incipient form of any project. Thus, they are given a say in important matters of their own city and also the possibility to evaluate a project and even take the initiative in that regard. After all, it is the city of its own citizens. This can be done in the context of the digitalization of the city: linking digital urban modelling with real-time input from both urban sensors and the human factor. This view has been supported by Roland Castro in his extensive study on the urbanism of Paris, in which he offers a different model of the global metropolis, a model that has in view the climatic and environmental changes that need to be taken into consideration in the world of today (Castro, 2018).

6. Economic impact of a smart city

First of all, the positive economic impact is obvious from the good examples around the world: one can easily observe the prosperous nature of smart cities. Equally important is the improved quality of life of citizens of a smart city, and this is again measurable and noticeable worldwide. Successful examples of such cities that have implemented sustainable and innovative public transport solutions abound in the specialized literature. Such cities boast a fluent and efficient public transport, with efficient and rapid transit systems, well-integrated metro networks, or cycling as a general means of transport. These examples can provide insights and encouragement for other cities to develop sustainable public transport strategies that will ultimately ease the life of the ordinary citizens. From the authorities’ point of view, the concept of a smart city, offering all the advantages highlighted above, also represents an important economic efficiency. A well-functioning public transport greatly contribute to savings for the local budget, because it helps with the traffic congestions, easing the life of travelers and ultimately of the business in which these operate. More fluent traffic flow means, after all, increased productivity, not to mention the immense cost saving that entails. Less pollution, less stress, and in the end a more attractive city for visitors and investors. It is well known how

important the infrastructure of a city is for foreign investors. Fluid traffic will add value to a reliable infrastructure, as well. Investing in reliable public transport means in fact investing in the future of the city and of the planet. By reducing the use of cars in public places, people will in fact save considerably: on gas, on parking taxes and so on. Green transport is not only more efficient, but in the end, it has lower costs and may even create a plethora of jobs developed around these green hubs that will eventually appear in cities. The impact on the environment is also immense, as this is a well-known fact, greatly contributing to a healthier life for the people.

Conclusions

If in the year 1967 the French President Georges Pompidou declared that 'We must adapt Paris both to the lives of Parisians and to the needs of the automobile', the time has come, in 2023, to completely rethink the relationship between a city, especially a smart city and urban mobility. At the same time, the world is slowly making the transition from traditional cars that are inefficient and polluting to electric cars and perhaps in the not-so-distant future even to autonomous cars that will interact, in turn, completely differently with the urban matrix. This difference is somewhat equivalent to that between the hard and soft components in a computer, as this autonomous system works organically, integrated, taking into account all the other components of a sustainable and environmentally friendly city.

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ENHANCING CITY MOBILITY THROUGH DIGITAL APPS: A STUDY ON THE EFFECTS OF E-SOCIETY

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Abstract: By delivering accessible and targeted transportation options, the integration of digital apps in urban contexts has the potential to revolutionize metropolitan mobility. This research looks at the influence of digital apps on city mobility and their implications for e-society. We investigate the influence of these apps on road congestion, public transportation utilization, environmental sustainability, and user experiences using a combination of data analysis and focus group interviews. The study employs a mixed-methods approach, combining qualitative observations from focus group interviews with app users with an extensive survey of the literature that lays the groundwork for comprehending the existing knowledge and research needs in the field of e-society and urban mobility. This research has ramifications for politicians, urban planners, and developers, who can use the findings to optimize urban transportation networks and improve city mobility. The study underlines the importance of ongoing research and collaboration among academics, industry, and policymakers in order to properly integrate digital apps into urban surroundings, providing equal access and long- term mobility. This investigation adds to the expanding body of knowledge in the subject of e-society by shining light on the effects of digital apps on city mobility. It emphasizes the potential of digital technologies to alter urban mobility and establishes the framework for future research into this critical convergence of technology and urban living.

Keywords: digital apps; city mobility; e-society; urban transportation; technology adoption

JEL Classification: O18

Introduction

The rapid progress of digital technologies in the past few decades has profoundly impacted several parts of our daily life, including urban transportation and mobility in the cities. Mobility is a key component of what is known as 'urban metabolism' (Clift, et al., 2015). This has significant implications for energy and pollution in the environment. Such mobility has also been a long-term challenge for urban authorities, who have limited capacity as well as significant demand, with upward pressure from urban population growth. Making urban mobility more sustainable has long been a primary objective. Sustainable urban mobility, according to Lam and Head (2012), refers to "the ease, convenience, affordability, and accessibility of travelling to one's destination with minimal impact on the environment and others". Researchers argue that "good urban design, behavior change, advanced technology, supportive policies, economic incentives, and city engagement and leadership" can improve accessibility as well as convenience (Lam and Head, 2012, p. 359).

As cities continue to struggle with traffic congestion, air pollution, and limited transportation resources, there is an increasing need to implement sustainable solutions that prioritize resource efficiency and promote ecologically friendly forms of transportation. Digital apps have an important role in affecting urban mobility patterns by influencing travel behavior and giving

alternatives to the use of private vehicles. Researchers can gain an understanding of how these technological tools can contribute to decreasing carbon emissions, improving public transit use, and encouraging the adoption of sustainable travel options by investigating the relationship between digital apps and sustainable urban mobility.

Despite the increasing number of users and potential benefits of digital apps for city transportation, there is a knowledge gap regarding their real consequences on urban transportation networks, particularly in cities such as Iași. While some studies have looked at various features of digital app usage in general, there is a need for a more in-depth look at how these apps affect city mobility. The evaluation of the equality issue in transportation is enabled by studying sustainable urban mobility in the context of travel digital apps. Access to transportation alternatives is critical in ensuring that all members of society have equitable mobility opportunities. By offering real-time information, inclusive route planning, and economical shared mobility services, digital apps have the ability to bridge transportation access gaps. Researchers can discover discrepancies and design interventions to address the needs of vulnerable groups, such as low-income areas or those with mobility issues, by evaluating the function of digital apps in promoting equitable access to transportation services. This inclusive approach to sustainable urban mobility can help to establish more equitable and socially just communities with accessible transportation options for all.

The purpose of this study is to obtain a better understanding of how Iași residents perceive the current state of public transport in relation to transportation digital apps. The following research questions are being addressed by the study:

1. What is the perception of public transportation among Iași citizens?
2. How frequently do they utilize digital apps for transportation purposes?
3. What are the notable advantages and disadvantages of these digital apps?
4. Additionally, what enhancements should be implemented in these apps to improve city mobility?

Given the research questions, a series of objectives have been formulated:

- Objective 1 (O1): To understand the perspective of citizens in Iași concerning public transportation.
- Objective 2 (O2): To determine the frequency of digital transportation app usage among citizens in Iași.
- Objective 3 (O3): To identify the primary strengths and weaknesses of the available mobility digital apps in Iași.
- Objective 4 (O4): To develop a comprehensive guide for the developers of mobility digital apps, incorporating suggested improvements provided by the citizens.

Understanding how digital apps affect traffic congestion, public transportation usage patterns, environmental sustainability, and user experiences is critical for improving urban transportation systems and guiding future planning and policy decisions. The research offers preliminary results and insights based on qualitative analysis as it is an exploratory study. It emphasizes the need for more thorough quantitative data to guide actual changes and legislative decisions in the area of digital mobility apps and their consequences on e-society, serving as an outline for future research.

1. Literature Review

A smart city is one in which information and communication technologies are widely used to improve operational efficiency, service quality, and the well-being of citizens. Digital technologies, as an important element of the smart city setting, provide precise analytics that enables further development of urban policy, particularly in the domain of urban mobility

(Kandt and Batty, 2021). The concept of smart mobility is heavily reliant on information and communications technology which is used in both backward and forward applications to enable the multiplication of solutions, improve usability, and support the efficient management of traffic flows, as well as collect citizens' opinions about the quality and usability of these services in social media (Benevolo, et al., 2016).

Because of smart mobility's direct impact on the quality of urban living and urban growth, public transportation has received a lot of attention in recent years. The primary goal of public transportation is to ensure connectivity and prevent traffic agglomerations. Traffic congestion has arisen as a critical issue impacting the sustainability and liveability of large cities, as well as rising megacities in developing countries (Zhao and Hu, 2019). Migrations in the population have a big impact on how smart mobility research is conducted. Understanding the mobility demands and behaviors of various population groups becomes essential for creating efficient smart mobility solutions as populations evolve and metropolitan areas see changes in demographics.

Even if it is often superficially looked at, the phenomenon of demographic migrations should give researchers food for thought. Today, cities around the globe are home to more than 3.8 billion individuals. Following the predictions provided by specialists, we can see that in a few decades, the urban environment will steal around 20% of the rural population (United Nations, 2019). If we add the issue of power consumption to this discussion, things get serious. A Eurostat report from the year 2018 shows us the following data: currently, 1% of the world's population consumes 0.54% of the world`s available energy. This ratio, however, applies when we consider the rural population. If the urban environment is taken into consideration, the situation changes radically: every 1% of the total urban population of the planet consumes 1.4% of the total energy (Eurostat, 2018). Thus, associating these data with those related to the trends of the massive growth of urban demography, one can easily see that one of the current priorities of the cities must be the smart allocation of resources and moderate energy consumption.

Digital apps have developed imposing technologies with the potential to revise city mobility by providing users with fast and targeted travel solutions (Shaheen, et. al., 2016). According to Benevolo et al. (2016), digital apps have the ability to reduce traffic congestion by providing real-time navigation, alternate routes, and congestion notifications. They also encourage greater use of public transit by providing features such as route planning, ticketing, and real-time schedules. Furthermore, incorporating digital apps improves accessibility and connectivity inside the city, resulting in increased city mobility and user pleasure. However, various user groups face issues and concerns around privacy, security, social equality, and accessibility (Science and Technology Options Assessment, 2014). While users are generally pleased with the apps' usability and usefulness, opportunities for improvement and user feedback channels are emphasized.

These apps provide a variety of functions, such as real-time navigation, ticketing services, and public transportation information, which allow users to navigate cities more efficiently and effectively. The remainder of this chapter takes a closer look at the main potential that digital apps present for city mobility, as well as the key concerns about using online apps. The digital applications that are accessible in the city of Iași are going to be analyzed, with a particular emphasis on those that are concerned with public transport. We seek to highlight the benefits and constraints of digital applications for urban public transit by examining each of the five digital apps available on the official app store in relation to prior research and studies. In-depth knowledge of the advantages and disadvantages these applications offer to citizens and the general effectiveness of the public transport system is the first step in order to better understand how these applications affect the sustainability, mobility, and effectiveness of urban public transportation.

1.1. Real-time navigation

Digital apps for transport often feature real-time guidance, which has completely changed how individuals move around cities (Kloeckl, Senn and Ratti, 2012). To give users accurate and current information on traffic conditions, road closures, and alternate routes, these apps make use of GPS technology and real-time data. The digital apps analyze data from a variety of sources, including traffic sensors and user inputs, and dynamically modify navigational instructions to assist users in quickly reaching their destinations (Leduc, 2008). Additionally, voice-guided directions and visual clues are offered by some real-time navigation apps, which improve user experience and lower the risk of getting lost. The digital app collects anonymized position and velocity data from users to determine the state of the roads (Barth, 2009). The information is then processed by Google, which produces a visualization of how busy or "free-flowing" the road is. Thus, urban mobility has been greatly enhanced by the inclusion of real-time navigation in digital transportation apps, which often results in time savings and less traffic on city streets.

1.2. Route planning

Digital transport apps with route planning capabilities are essential for assisting users in selecting the most practical and effective routes. These apps can produce personalized route suggestions that are catered to the needs of each user by taking into account elements like traffic congestion, public transportation timetables, and user preferences. As has been underlined above, some apps even employ real-time data to automatically change routes based on the flow of traffic, making sure users are constantly following the quickest or most practical route. In order to get to their destinations, users can mix several means of transportation, such as walking, cycling, and public transit, thanks to route planning functionalities. A greener and more environmentally friendly urban environment is produced as a result of this integration, which promotes sustainable mobility and lessens dependency on personal vehicles (Banister, 2008).

The use of digital tools for route planning in the e-society is not without challenges, though. Over-reliance on technology and a possible loss of human decision-making are two major issues. While computerized route planning apps offer useful ideas, they do not always take user preferences or contextual considerations into account that an actual human might (Parasuraman and Manzey, 2010). This may lead to less-than-ideal routes or a lack of adaptability in the face of unforeseen circumstances or individual preferences. Additionally, relying heavily on computerized route planning may cause users to have less spatial awareness and navigational expertise (Brügger, Richter and Fabrikant, 2019). If individuals only use app-guided navigation, they could become less familiar with the city and less interested in the surroundings.

1.3. Ticketing

Another crucial feature offered by digital transit apps is ticketing. Mobile ticketing is the act of purchasing, validating, or starting a journey using a mobile device. There are a number of technologies available in mobile devices that can be used to implement mobile ticketing solutions, including SMS and phone calls, Wi-Fi and 3G/4G, NFC, BLE, and QR Codes (Campos Ferreira, Galvão Dias and Falcão e Cunha, 2020). Users can quickly buy and save tickets directly on their phones rather than depending on paper tickets or cards. This makes the ticketing procedure faster and more effective by eliminating the need for lines at ticket booths or vending machines. To provide a seamless and frictionless experience for customers, digital ticketing apps frequently provide a variety of payment alternatives, including mobile wallets, credit cards, and even contactless payments. Additionally, these apps can offer customers personalized ticket recommendations based on their travel habits, presenting affordable choices

and encouraging environmentally friendly transportation methods (Mezghani, 2008). This convenience encourages a cashless society, lowers the possibility of physical tickets being lost or stolen, and streamlines the ticketing procedure for both passengers and transit companies.

The use of digital apps for ticketing in the e-society is not without its drawbacks, though. The issue of inclusion and accessibility is one of the main concerns. Not everyone has access to smartphones or the digital literacy skills required to use these apps correctly. As a result, some sections of the population may not be able to use digital ticketing services, leading to a digital divide (Campos Ferreira, Galvão Dias and Falcão e Cunha, 2020).

1.4. Public transportation information through crowdsourcing

Connectivity is essential for smart mobility since it allows for dynamic control by public officials and the real-time transmission of traffic data. Users of mobile apps can instantaneously receive often changing mobility-related data, such as parking availability, traffic conditions, and delays, ensuring smart and seamless travel. By utilizing the combined knowledge and real-time data from a broad user base, crowdsourcing enables people to submit details about their experiences using public transit (Pinna, et al., 2017). This data is gathered and disseminated to other commuters, enabling people to make educated decisions, select efficient routes, and modify their travel schedules. Additionally, it makes it possible for service providers and transportation authorities to quickly locate and address problems, enhancing user contentment and service dependability.

However, the accuracy and dependability of crowdsourced data pose major issues. For example, there may be variances in the data's quality and authenticity because it is user-generated (Roman, 2009). For other users, inaccurate information or subjective experiences can cause confusion or provide misleading direction. Crowdsourcing may also have participation bias problems, in which some groups or demographics are overrepresented and produce inaccurate or biased data. Implementing procedures to validate and sift through crowdsourced data would ensure its reliability and applicability. User-generated data collection and sharing also raise privacy issues, as suggested by Brabham (2013). It takes careful thought and strong privacy controls to balance protecting privacy rights and utilizing crowdsourcing data for the benefit of smart city mobility.

1.5. Main issues and concerns regarding the usage of digital apps in city mobility

Urban transportation has clearly been altered by digital apps, but there are still some worries and problems that need to be resolved. Privacy concerns with the data obtained from mobile phones or satellite navigation systems are one of the biggest issues with the location technologies presented here (Leduc, 2008). Although the public may not believe this or comprehend the motivations behind gathering the information, the data is made anonymous before being utilized to describe the state of the roads (Cruickshanks and Waterson, 2011). There is a need to maintain strong security measures and data protection policies because these apps collect and handle enormous amounts of user information, including personal and geographical data. People in the public want to know what information is being gathered, if it can be used to identify specific people, why the transportation authorities require it, and whether it can lead to the imposition of fines. To convince the public that their privacy is not violated in any way, these concerns must be answered.

Dependence on digital ticketing apps also poses privacy and security issues, as it happens in the case of most digital apps (McDonald and Cranor, 2008). These apps gather and handle very sensitive financial and personal data, and if they are not appropriately safeguarded, there is a possibility of data breaches and unauthorized access. To ensure that user data is protected, it is essential to implement strict security controls and privacy guidelines. The ticketing procedure

may also be interrupted by technological hiccups or faults that cause system failures or malfunctions. In order to prevent such problems and guarantee consumers' continual access to ticketing services, it is clear that ongoing monitoring, maintenance, and backup plans are required.

The ease of use and inclusivity of these apps are further issues. Every societal member, including those with disabilities or minimal digital literacy, should be able to access digital transportation solutions. Heavy reliance on digital technology could also result in a digital divide (van Dijk, 2006) where people who lack phones or steady internet access fall behind. To address these issues and guarantee equal access to smart mobility solutions, a balance between digital technologies and conventional transportation infrastructure is essential.

If the primary goal of the research up to this point was to thoroughly explain the benefits as well as the drawbacks associated with the features of digital applications for smart mobility, the following part will describe the major digital apps offered in the city of Iași. To delve deeper into the practical implications of the features of digital apps in a specific local environment, such as the city of Iași, these brief case studies become crucial. The connection between the literature review and the case studies is extremely important because it closes the gap between theoretical understanding and practical implementation, providing insightful information about the particular situation and user viewpoints. The approaches used in the case studies improve the validity and dependability of the research, highlighting the value of researching digital mobility apps in a local urban environment.

2. Brief case studies: city mobility apps in Iași

In the Sustainable Urban Mobility Plan for the Iași Growth Pole for the post-2020 period (P.M.U.D., 2023), 67% of respondents named heavy traffic as the municipality of Iași's main issue, and 76% said they were dissatisfied with the frequency of the public transport provided. Taking into account this information, we think that digital mobility applications for the city could improve the standard of Iași's public transport by giving users the chance to learn about traffic patterns in real-time and facilitating their movement around the city.

Following extensive investigation, we have determined that HereItIs (2023), Tranzy (2023), and Moovit (2023) are the three most pertinent transit apps for Iași, Romania. We will evaluate each app's benefits and drawbacks in connection to smart mobility in Iași using the theoretical foundation provided by the literature review. It is important to note that the other two applications available when checking the official app stores, 24Pay and Iași-City Report, have functions that are distinct from those of Iași's public transportation system (such as tickets and online payments for 24Pay) or offer features that are unconnected to Iași's public transportation system.

The digital apps HereItIs (3.8 stars) allows users to navigate the city using nearby buses and trams. It gives consumers current information on routes, itineraries, and arrival times so they may make informed plans. The app provides thorough maps, detailed instructions, and real-time updates for a convenient driving experience. Users can enjoy a user-friendly design, download offline maps, and track exact arrival times. However, the app's coverage is sparse, and real-time updates can contain inaccuracies. HereItIs may lack other functionality like ticket purchasing and interaction with other modes of transportation when compared to other apps.

Tranzy (3.3 stars) is one of the most popular digital mobility apps in Iași, Romania, an exciting municipality noted for its active urban transportation system. The app allows its users to effortlessly plan itineraries that mix buses, trams, and other kinds of transit. The software gives users real-time information about public transit schedules, routes, and expected arrival times, enabling them to make informed decisions and optimize their commute. Tranzy also provides features such as route planning and user feedback methods, with the goal of improving usability and providing a seamless experience for users navigating the city. Looking at the weaknesses

of the apps, we have noted unexpected technical issues or app crashes that have also been observed by some users that find the app's interface to be challenging. These issues can be upsetting for users who depend on the app for real-time information and route planning. Moreover, the app has limited language assistance, focusing mostly on the regional tongue, which can be difficult for travelers or non-native speakers.

A more well-known digital app called Moovit (4.2 stars) provides thorough navigation support for public transit, including buses and trams. It gives customers access to real-time information about schedules, routes, and arrival times to help them plan their journeys effectively. Moovit promises a seamless travel experience by providing real-time updates, notifications of service interruptions, and step-by-step directions. Its broad coverage, which provides comprehensive access to Iași's public transportation routes and schedules, is one of its main advantages. For accurate information on arrival timings, bus occupancy, and delays, the app also makes use of crowdsourcing data. The seamless integration of Moovit with bike-sharing and ride-hailing services also gives consumers more options for getting around. Regarding Moovit's drawbacks, one of them is the presence of in-app advertisements, which some users may find intrusive or annoying as they use the programme. Such commercials may interfere with the user experience and make it more difficult to utilize the app for navigation. A higher battery drain may result from Moovit's reliance on location services and real-time updates. Users who significantly rely on the app for their daily commute needs may have issues because this could cause their device's battery to drain more quickly, necessitating regular charges. The complexity of Moovit's user interface is an additional weakness. With so many features and options accessible, novice users can find it difficult to completely understand the app's functionality, which could cause confusion or dissatisfaction. Moreover, some users have claimed that the app's real-time feature occasionally contains inaccuracies that can cause confusion or missed connections.

To sum up, we created a small table (Table 1) to address the main disadvantages and disadvantages of the available digital apps for mobility in Iași:

Table 1. Advantages and Disadvantages observed in the digital mobility apps available in Iași

Digital App	Advantages	Disadvantages
HereItIs	+ Real-Time Updates + User-Friendly Interface + Offline Functionality + Crowdsourced Data	- Inconsistent Accuracy - Limited Coverage - Lack of Additional Features - Occasional Glitches
Tranzy	+ Multi-Modal Options + Customizable Notifications + Community Interaction + Additional Features (trip planner, real-time alerts, transportation means filter)	- Occasional Glitches - Limited Language Support - Interface Complexity -Inconsistent Accuracy
Moovit	+ Extensive Coverage + Crowdsourced Data + Integration with Other Modes + Additional Features (trip planner, real-time alerts, bike routes)	- Battery Drain - Advertisements - User Interface Complexity - Inconsistent Accuracy

3. Data and Research Methodology

This study uses the focus group methodology to explore the effects of local digital apps on city mobility. We intended to obtain a better understanding of the app's impact on travel behavior, traffic congestion, public transportation usage, and user satisfaction in the context of Iași's urban setting by evaluating the users' experiences and perspectives through focus group discussions. A focus group or in-depth group interview is a qualitative research technique that focuses on collecting data through the interaction between group members, data related to a problem established by the researcher in advance (Chelcea, 2004).

Considering these aspects, we think that this is the best method in order to understand more deeply the innovation process of the mobility infrastructure of Iași. In order to make the focus group relevant for the current research we selected the participants according to the variables age, frequency of using public transportation, the degree of digital literacy and the place of origin. Based on the recommendations of the relevant research in the field (Banister, 2008; Benevolo, et al., 2016; Kandt and Batty, 2021) we selected the individuals starting from the idea that there should be a mix of values for each of the selected variables.

In addition, it's important to mention that although the article was published in English, the focus group was held in Romanian. Focus group members can freely communicate their ideas, opinions, and experiences without encountering any language obstacles because the focus group will be conducted in the local tongue. This choice offers a more accurate portrayal of the participants' points of view and recognizes the significance of portraying the subtleties of the local setting. As a thorough reference for the methodology used in the study, an appended interview guideline has been provided, covering the subjects and questions covered throughout the focus group meeting. In the process of building the focus group, we took into account several rules recommended by the relevant research (Bader and Rossi, 2002). Thus, we designed the tool considering three large categories of items:

- Questions to test the degree of familiarity of individuals with the digital applications related to traffic in Iași;
- Questions regarding the personal experience of individuals with these online platforms;
- Questions regarding possible ideas for improving the digital transport infrastructure in Iași.

In the next part of the research, we will address the main results and the interesting observations that we understood after the moderation and analysis of the focus group.

4. Results and Discussion

The focus group's findings on Iași's public transit revealed a mix of favorable and unfavorable comments in relation to the first question. Some responders praised recent upgrades, including the painting and customization of public transport vehicles and the installation of billboards showing trams and buses arrival times. These were seen pleasing because they facilitate travel and enhance travelers' wellbeing.

Others, though, complained about how inaccurate the schedules and applications for public transportation were. The fact that trams are frequently crowded was also noted as a persistent issue. Moreover, N.G., male, 27, brought up the fact that, "regardless of comfort improvements, Iași public transport still has a fundamental infrastructure issue that results in a lack of a distinct boundary between the space designated for it". Another participant felt forced to utilize their personal vehicle rather than utilize public transportation due to the city's poor traffic management and architectural constraints.

The respondents highlighted the following as the biggest issues with mobility in Iași:

- Public transportation's effectiveness and predictability. Prioritizing and synchronizing travel periods would help public transport systems become more effective and of higher quality.
- Congestion and traffic on buses. This is regarded as a significant issue with Iași's public transport, yet it cannot be resolved solely by applications.
- Advertising and inadequate visibility of transit applications. According to some respondents, user awareness of these applications is insufficient, which hinders uptake and the input necessary for improvement.

Some respondents mentioned using apps like Moovit, HereItIs, and Google Maps to get information about public transportation routes and arrival times in response to the second question about how frequently the respondents use digital apps for transportation purposes and what types of apps they use. For example, A.G., female, 43, mentions: "I prefer HereItIs because it also shows me a map and, in this way, when I'm at a station, I figure out if I should walk to the next stop to catch another connection or stay there."

The accuracy and usability of these apps, however, have often been criticized as being primarily problematic. Google Maps was regarded as the most popular, satisfactory, but perhaps not ideal, solution. The rise of Google Maps at the expense of other popular applications seemed to be a phenomenon that specifically affected the platform's exceptional effectiveness and widespread use by users. The expressed preference for Google Maps must be considered in the future development and enhancement of digital mobility products. While some survey participants continued to use Google Maps, others did not think that public transportation apps were important or necessary, especially if they were familiar with the city routine and local public transportation. Additionally, several respondents appreciated the boards that were present in the stations and thought that they provided a suitable alternative for calculating the waiting time. Thus, even though there are plenty of apps available, user preferences and experiences vary, and some apps are thought to be more inaccurate and problematic than others. But, as C.T., male, 54, put it: "these applications are necessary and will become more and more useful. Because they save us time".

Diverse viewpoints on the benefits of digital apps were stated (Q3), and a hot topic in the focus group was the functionality of the real-time verification system for digital public transit applications. Some respondents said they didn't think this system was respected and that there were times when the data displayed wasn't correct. They highlight the differences between the predicted arrival time and the actual arrival time of the means of transport and believe that the applications do not offer helpful assistance in this regard. Other respondents, on the other hand, value the real-time verification system and find it helpful in circumstances when they lack access to precise information regarding the arrival of public transit. They view these apps as a resource of knowledge that enables them to choose between waiting for a specific method of transit or choosing a different link.

Additionally, some respondents expressed frustration with the frequent delays in public transportation and thought that their experience using the programmes was negatively impacted by the lack of adherence to a set schedule and accurate anticipated times. They emphasize the need to upgrade transportation facilities, put policies in place to lessen traffic and give public transportation priority.

Related to the lack of e-ticketing functionality in the transport applications available in Iași and the implementation of these functions in the Moovit, Tranzy and HereItIs applications are varied. According to some responders, this inclusion is unnecessary because there are already other methods for purchasing tickets, such as the 24Pay app or the ability to use a card to make a direct payment at the point of service. For example, D.F., female, 31 concluded: "I think I'm

oversaturated with apps, when I hear the idea of installing a new app my hair stands on end. I find 24Pay works well enough...". Others also believe that the management of various applications and accounts would confuse users and that the integration of the ticketing function could complicate the process of utilizing the applications. On the other hand, several respondents said they valued the simplicity of making a payment directly from their phone and would be amenable to this feature being offered in every transport apps. They view the inclusion of the ticketing feature as a logical development that will be good for users.

In response to the fourth question, the focus group discussions revealed some key changes that respondents would make to public transport applications, such as:

- Putting in place a feature that alerts users to busy routes and provides alternate routes to avoid them. In this regard, the response of male, 21-year-old C.C. is noteworthy: "The largest problem of public transport in Iaşi is the congestion on the bus, from both the transport itself and the traffic. And it's not a problem that can always be fixed by the application... I believe that a system similar to Waze could be put into place. Thus, the app would show you the congested routes and suggest an alternate route so you could go somewhere else. They would also show you the trams that are on the line so you would know not to go to the station after one and instead take the next one. Maybe there is a way to streamline this. It could be helpful, I believe".
- Supplying up-to-the-minute data on tram availability and the ability to arrange the route appropriately. To emphasize this recommendation, we use the testimonial of A.G., female, 43: "In Chișinău, in addition to the service they offer to travelers to be informed when buses arrive at the stations, how long they have to wait, they (public transport managers jointly) use the reports provided by Tranzy to improve their public transport. Well, you, as a carrier, as the one providing the Public Transport service, should have access to such reports and improve the mobility system. If in a month you see that there is a constant delay on sector A, you have to take action, because otherwise people will surely appreciate public transport from the wheel of their personal car."
- To help enhance the travel experience, encouraging a more responsible and accountable mindset on the part of users and society at large.

The focus group discussion also revealed a concern for elderly or less tech-savvy individuals who might find it challenging to use applications and would rather buy tickets and look for alternative routes the old-fashioned way. Furthermore, it may be difficult to use transit apps efficiently if you are unfamiliar with utilizing smartphones and apps or lack expertise doing so. According to the comments, tourists, particularly those who are unfamiliar with the area or do not reside in the individual city, who may have trouble utilizing these applications, are other groups of people who may be adversely affected by these local applications. For them, navigating through apps and comprehending functionality can be challenging. Moreover, the usage of these digital mobility apps by visually impaired users may be constrained by the absence of accessibility and modified functionality (such as vocal assistance). Applications that do not offer voice assistance or other features designed for this set of users may be difficult for people with visual impairments to use.

In the end of the discussion, there were some worries about the detrimental consequences of using programmes like Google Maps too frequently. Relying on a single app for public transport information can be troublesome if there are technical problems or a brief outage of the service.

Based on the needs and suggestions of users interviewed for the development of public transport applications, we have created a short guide for developers of digital transport applications with tips that can help improve their user experience and efficiency:

- Boost app visibility: Invest money on app marketing and advertising to get more users to download and use the app. Make sure your target audience knows about and can use the app by using the right marketing channels. This would also help the optimization of the app: having more users who express their opinions regarding certain functionalities of the app helps the developers of these to understand what should be optimize in the app.
- Put efficiency and predictability first: Improve app functionality to deliver real-time data on routes, transportation options, and anticipated journey times. To minimize user delays and annoyance, make sure that trip times are coordinated and timed properly. Collaboration with the local public transportation managers ought to be promoted in this regard.
- Offer Alternative Routes: Implement functionality that provides users with different routes when there are backed-up routes, or traffic problems. Users will be able to identify faster or less congested routes and avoid congestion as a result.
- Integration with other platforms and services: Take into account integrating the application with additional relevant ones, such as electronic payment platforms, voice assistance or offline mapping applications. This will simplify the app's use even further and provide users with a more seamless and comprehensive experience.

5. Limitations of the study

It is important to recognize, though, that the conclusions drawn from focus groups could give a distorted picture of reality. Focus groups have inherent limits in terms of representativeness, despite the fact that they can yield insightful qualitative information and record participants' subjective experiences. Future research projects should combine focus groups and quantitative analytical methods to produce a thorough and representative study. The present piece is the result of a preliminary investigation into the function and citizens perception of mobile digital apps. Researchers can gain a more comprehensive knowledge of the role of mobility digital apps by incorporating quantitative data gathering methods, like as surveys or data analysis from app usage, allowing for a wider and more accurate representation of the population under study. The reliability and validity of research findings can be improved by this multifaceted approach, allowing for a greater understanding of the intricate dynamics related to these digital platforms.

Conclusions

The expanding effect of digital apps in urban contexts has piqued the interest of policymakers, academics, and urban planners, as they hold the promise of dealing with crucial city mobility concerns. Smart mobility’s main goal is to make it easier for individuals to move throughout a city, which leads to positive effects: less traffic, shorter travel times, cheaper transport, less pollution, less noise pollution, and increased safety when moving around (Benevolo, et al., 2016).

We used the focus group as an instrument to gain useful information from local citizens about their experiences, issues, and views of using the available apps for local city mobility. Participants had the opportunity to share their experiences, exchange ideas, and provide granular feedback on the apps' functionality, usability, and impact on their travel behavior through interactive group conversations. The focus group debates allowed us to gather a varied variety of perspectives and identify the benefits and drawbacks of the current apps as digital software for improving city transportation in the setting of Iași. The main results of this article refer to how developers of public transportation applications can optimize them in such a way that they meet the needs of citizens.

The findings of this study add to the growing body of knowledge on the effects of digital apps in urban environments, as well as inform potential improvements to digital mobility apps, with the ultimate goal of optimizing urban transportation systems and promoting sustainable and efficient city mobility in Iași and beyond.

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EXPLORING THE INFLUENCES ASSOCIATED WITH USING MOBILE PHONES AS AN INFORMATION SOURCE BASED ON A MULTI-TECHNIQUE APPROACH AND WVS DATA

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Abstract: Based on different techniques and tools for exploring large amounts of data, this paper aims to identify the most resilient influences of using mobile phones as information sources from the most recent and comprehensive dataset of the World Values Survey (TimeSeries 1981-2022, v4.0). One of the contexts is the increasing role of "smart mobility" as a significant pillar of smart cities, where both aim for better transformations of the way we live and work. DK/NA treatment and many rounds of selections based on Adaptive Boosting in the Rattle library of R, PCDM, the LASSO pack, together with different types of regressions, and the NOMOLOG tool and command (for generating prediction nomograms) in Stata contributed to identifying the five most salient influences in a classification model with no evidence of collinearity and good-to-excellent accuracy of classification (AUC-ROC>0.87). The first four (five-point frequency scale from daily to never, identical to the one of the target) are about using other channels or information sources, namely social media (Facebook, Twitter, etc.), talking with friends or colleagues, radio news, and e-mail. In addition to these four, a strong influence also has the birth year (all five positively correlated with the outcome), leading to the respondent age as having a negative correlation with the target.

Keywords: World Values Survey; mobile phones as an information source; data mining techniques; most resilient influences

JEL classification: C55

Introduction

Smart mobility is an essential element of smart cities (Paiva, et al., 2021), utilizing technology and innovation to enhance transportation systems (Mangiaracina, et al., 2017). Its main objectives are to improve efficiency, sustainability, and overall transportation quality in urban areas, making cities more accessible and livable for residents and visitors. The essential aspects of this type of mobility within smart cities include efficient and sustainable transportation (Mao, et al., 2020), seamless integration (Pribyl, et al., 2022), safety and security (Tokody, et al., 2018), data-driven decision-making (Sarker, 2022), and an enhanced user experience (Rao and Prasad, 2018). Data-driven decision-making relies on the collection, analysis, and real-time monitoring of data from various sources, such as sensors, GPS devices, mobile applications, and connected vehicles (Zhang, et al., 2011). This data helps understand travel patterns, optimize routes, and make informed decisions (Lucic, et al., 2020). The enhanced user experience focuses on improving the overall journey for commuters. The latter includes providing real-time information through mobile apps (Diamantaki, et al., 2015) or digital signage about transit schedules, traffic conditions, and parking availability (Zantalis, et al.,

2019). It also means simplifying ticketing and payment systems to make transportation services more accessible and user-friendly (Battarra, et al., 2018).

Mobile phones play a significant role in providing information in the particular context of smart cities and mobility. They are sources of real-time travel information (Li, et al., 2020), offering routes, traffic updates, public transportation schedules, estimated arrival times, and alternative transportation options through dedicated mobile applications or services. Mobile phones equipped with GPS technology and mapping applications act as navigation tools, helping users find their way and discover points of interest in urban areas. They also facilitate mobile ticketing and contactless payments for transportation services (Dinning and Weisenberger, 2017). Additionally, mobile phones enable users to provide feedback and report issues directly to authorities, improving safety and infrastructure maintenance. Moreover, by gathering data on users' travel patterns and preferences, this type of phone offers personalized travel recommendations (Logesh, et al., 2018).

In summary, mobile phones are crucial for accessing information in smart cities and mobility (Thompson, 2016) (Al-Turjman, et al., 2022). They empower individuals with real-time travel information, navigation assistance, mobile ticketing options, and personalized recommendations, enabling them to make informed decisions, navigate efficiently, and engage effectively with the transportation system.

When examining the most recent and comprehensive dataset of the World Values Survey, which includes a question and a corresponding variable regarding the frequency of using a mobile phone as an information source, five others proved high correlations with it. This supplementary analysis using many data mining tools and variable selection techniques together with some others, starting from datasets of the same provider (Kushlev and Proulx, 2016) (Post, 2016) (Xu, 2020) expands the viewpoint on the topic above. In addition, it can bring meaningful ideas regarding the proper user interface (UI) design for future mobile operating systems and many other dedicated mobile applications in the specific context of smart cities and mobility. The latter applies because the user interface is the user's first contact with any application, regardless of its functionality, complexity, and performance (Wu and Li, 2020). And its success usually decides the fate of the application (Sun and May, 2013) (Moran, et al., 2018).

1. Data and Methods

This article started from one of the most comprehensive World Values Survey (WVS) datasets. The latter (version 4.0, WVS_TimeSeries_4_0.dta) includes 1,045 variables and 450,869 raw observations. It served all selection rounds. Its corresponding .csv export meant for the 1st selection round using the Adaptive Boosting technique (Karabulut and Ibrikci, 2014) in R was preceded by designing, testing, and running a script sequence responsible for removing the DK/NA values (Tsikriktsis, 2005) of all variables (Do not Know/No Answer/Not Applicable) coded by WVS as negative ones, artificially increasing the scales, and not beneficial for data mining and also by a simple binary derivation of the target variable (E260BBin - Listing A1, Appendix A). The results of this 1st round of selections using Adaptive Boosting served as input for the 2nd one using the PCDM tool in Stata (Homocianu and Airinei, 2022), based on pairwise correlations (Listing A2, Appendix A) and considering both forms of the outcome. The results of this 2nd round were input for the 3rd one based on two commands in the LASSO pack (Ahrens, et al., 2020) in Stata (Listing A3, Appendix A), namely RLASSO (known for removing overfitting) and CVLASSO (known for performing random cross-validations).

The final selection phase measured the existing collinearity between the remaining influences (those resulting from the 3rd round) using a matrix with correlation coefficients (Schober, et al., 2018).

Finally, many models based on different regressions for both forms of the outcome (e.g., *logit*, *scobit* (Tay, 2016) and *probit* (Dey and Astin, 1993) for the binary form of the target variable and *ologit* / ordered logit (Fullerton, 2009) and *oprobit* / ordinal probit (Daykin and Moffatt, 2002) for the original form considering a scale) served to test the remaining influences. Some other tools for reporting default and custom model evaluation metrics, such as ESTOUT (Jann, 2005) (Jann, 2007) and MEM (Homocianu, D., and Tîrnăucă, 2022) in Stata additionally served when generating the tables with coefficients and errors corresponding to all the models obtained.

In addition, a prediction nomogram resulted after using the *nomolog* command (Zlotnik and Abraira, 2015), launched immediately after generating the logit model.

2. Results and Discussions

After performing the 1st selection round using Adaptive Boosting (in the Rattle library - https://rattle.togaware.com of R – Figure 2) on the .csv export of the cleaned form of the WVS dataset, a set of 23 variables resulted (Figure 1).

```
Summary of the Ada Boost model:

Frequency of variables actually used:

COUNTRY_ALPHA          E261B          E253B
           48             40             25
        E259B           S012          E254B
           13             13             12
        E262B           X002           mode
           12              8              7
        E250B          E258B          E255
            6              6              5
        S022           S006          S023
            4              3              3
        X003        H006_02          S007
            3              2              2
        A104           E116       H002_03
            1              1              1
        S020          X003R
            1              1
```

Figure 1. The result (as frequency of variables used) of the first selection round using Adaptive Boosting in Rattle and the cleaned form of the dataset in the .csv exported format

The next step (2nd selection round) was to find the number of valid observations for the target variables. The PCDM custom command was used for that (*pcdm E260B E260BBin*). Only N=178339 non-NULL records resulted. That helped to set up the minimum support parameter (N/2+1, meaning at least half of the total amount of valid observations for the target) for the next launch of PCDM together with the maximum accepted p-value (0.001) and the minimum acceptable absolute value of the correlation coefficient (0.1). This 2nd launch relied on both forms of the outcome and considered only 22 of those 23 variables resulting from the 1st round (all except the COUNTRY_ALPHA – string variable), namely *pcdm E260B A104 E116 E250B E253B E254B E255 E258B E259B E261B E262B H002_03 H006_02 mode S006 S007 S012 S020 S022 S023 X002 X003 X003R, minacc(0.1) minn(89170) maxp(0.001)* and *pcdm E260BBin A104 E116 E250B E253B E254B E255 E258B E259B E261B E262B H002_03 H006_02 mode S006 S007 S012 S020 S022 S023 X002 X003 X003R, minacc(0.1) minn(89170) maxp(0.001)*. The intersection of results for this 2nd round meant only 14 variables, namely E253B E254B E259B E261B E262B S007 S012 S020 S022 S023 X002 X003 X003R and served as input for the following selections using RLASSO and CVLASSO. The 1st run of RLASSO for both forms of the outcome (*rlasso E260B A104 E253B E254B E259B E261B E262B S007 S012 S020 S022 S023 X002 X003 X003R* and *rlasso E260BBin A104 E253B*

E254B E259B E261B E262B S007 S012 S020 S022 S023 X002 X003 X003R) selected only seven variables (at the intersection of both forms), namely A104 E253B E254B E259B E261B E262B X002. The 1st for CVLASSO (starting from these remaining) dropped only A104. In the 2nd run for both RLASSO and CVLSSO, both forms of the outcome and the remaining six variables did not eliminate others (full description of these variables in Table A1 and descriptive statistics for most of them in Table A2, both in the Appendix section).

	E253B	E254B	E259B	E261B	E262B	X002
E253B	1.0000					
E254B	0.3947	1.0000				
E259B	0.0628	0.2058	1.0000			
E261B	0.4925	0.3242	0.2004	1.0000		
E262B	0.7079	0.3266	0.0980	0.6844	1.0000	
X002	-0.3741	-0.0771	0.0997	-0.1718	-0.2847	1.0000

Figure 2. Collinearity view using a matrix with correlation coefficients for the remaining influences

Next, when verifying the existing collinearity (Fig.2 - *pwcorr E253B E254B E259B E261B E262B X002*), a matrix with correlation coefficients emerged and suggested two collinear combinations of two variables, namely E253B-E262B and E261B E262B, with coefficients indicating moderate to strong correlation between predictors according to (Schober, et al., 2018). Only E262B (Information source: Internet) dropped in this case (Table A2, the Appendix section). That is due to being collinear with both E253B (Information source: social media (Facebook, Twitter, etc.)) and E261B (Information Source-E-mail).

After this step, many regression models resulted. The latter confirmed again the remaining five variables (see Table A3, the Appendix section), namely E253B, E254B, E259B, E261B, and X002.

The prediction nomogram (Figure 3) emerged after building the binary logistic model in Table A3, the Appendix section (model 1). It corresponds to five resilient influences, a decent number of intersecting observations and afferent support (87741 records), a considerable R^2 (0.33), and a good accuracy of classification (AUC-ROC of 0.87).

The maximum theoretical probability for the most advantageous combination of variable values (extreme right) is high. It indicates a value of more than 0.99 (or .99). This graphical construct also reflects the magnitude of marginal effects (better comparability than with raw coefficients) for the corresponding variables. In addition, this nomogram serves to understand the cumulated effect size by considering the amplitude of any scale easily noticeable in this visual representation. If considering the latter, the descending order of importance (Figure 3) will start with E261B (E-mail) and E253B (social media (Facebook, Twitter, etc.)), it will continue with X002 (birth year), and end with E254B (Talk with friends or colleagues) and E259B (Radio News). As expected, all five appear in the upper part (Top 10) of the selected results given by Ada Boosting (Figure 1) in terms of importance if considering the number of splits when automatically building classification trees.

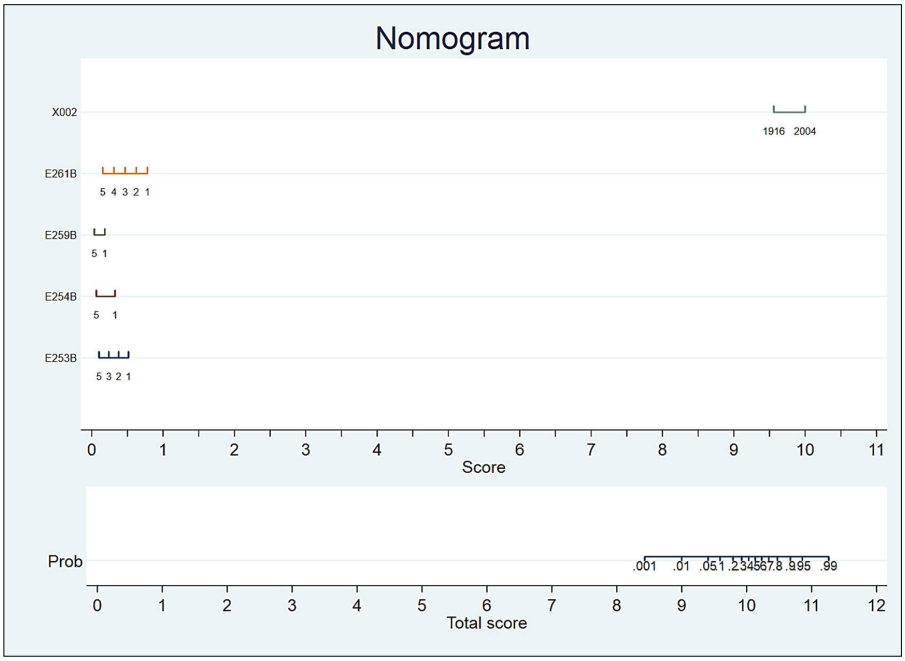

Figure 3. Prediction nomogram corresponding to the best model as accuracy and resilience

When checking the wave coverage of those five variables and corresponding influences above in the chronology of the World Values Survey, only the last two waves seem to include the afferent questions and answers, namely Wave 6 (2010-2014) and Wave 7 (2017-2022). The only exception was E253B, included only in the last wave.

Although identified as existing in the dataset and corresponding to the results obtained after a variable search using the <<Internet>> keyword, four other related influences did not prove significant and robust enough to be selected by the methods mentioned in this paper. Therefore, they are not in the final models (Figure 3). It is about Political Actions using the Internet: Searching information about politics, Political Actions using the Internet: Signing an electronic petition, Political Actions using the Internet: Encouraging other people to take any form of political action, Political Actions using the Internet: Organizing political activities, events, protests, etc. The same stands for the rest of the variables identified when manually searching for them using the <<information>> keyword (Information source: Daily newspaper, Information source: News broadcasts on radio or TV, Information source: Printed magazines, Information source: In-depth reports on radio or TV, Information source: Books, Information source: TV news, Government has the right: Monitor all e-mails and any other information exchange and Government has the right: Collect information about anyone living in the country) or the <<Government has the right>>, <<the right>> or <<commerce>> expressions (Worries: Government wire-tapping or reading my mail or e-mail, Government has the right: Keep people under video surveillance in public areas, Confidence: The Press, Confidence: The Free Commerce Treaty).

All influences in Figure 3 also give some clues regarding the simplicity requirements for any mobile application user interface.

Conclusions

In the context of the increasing role of "smart mobility" as a significant pillar of smart cities and mobile phones as crucial for accessing information, this paper expands the existing viewpoints in the scientific literature on the latter with considerations regarding the most associated influences with mobile phones as information sources as resulting from an objective analysis of the most recent and comprehensive version of the WVS datasets (Time Series, v4.0, 2023). Five most salient influences and a classification model with no evidence of collinearity and good-to-excellent accuracy of classification resulted after some processing, selection, and reporting steps, namely DK/NA values treatment, and using Adaptive Boosting in Rattle (library of R), and PCDM, RLASSO, CVLASSO, ESTOUT, MEM and NOMOLOG in Stata. The first four influences have a positive correlation with the outcome. They concern other channels or information sources. The fifth one is a strong influence corresponding to the birth year. As expected, the latter indicates that younger respondents are more prone to using mobile phones.

Acknowledgments: For allowing the exploration of the datasets and the agreement to publish the research results, the author would like to thank the World Values Survey and all supporting projects.

Data Availability Statement: The datasets used in this study belongs to the World Values Survey (WVS TimeSeries 1981 2022 Stata v4 0.zip).

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Appendix A

Listing A1. Simple Stata script for deriving the binary form of the target variables (WVS datasets) and checking its values when comparing them to the ones of the original form

```
1 generate E260BBin=.
2 replace E260BBin=1 if E260B!=. & E260B>=1 & E260B<=4
3 replace E260BBin=0 if E260B==5
```

Listing A2. Simple Stata script for selecting the variables most correlated with the outcome using the PCDM custom command

```
1 pcdm E260B E260BBin
2 pcdm E260B A104 E116 E250B E253B E254B E255 E258B E259B E261B E262B H002_03 H006_02 mode S006 S007 S012 S020 S022 S023 X002 X003 X003R, minacc(0.1) minn(89170) maxp(0.001)
3 pcdm E260BBin A104 E116 E250B E253B E254B E255 E258B E259B E261B E262B H002_03 H006_02 mode S006 S007 S012 S020 S022 S023 X002 X003 X003R, minacc(0.1) minn(89170) maxp(0.001)
```

Listing A3. Simple Stata script for performing consecutive selections until convergence using the RLAASO and CVLASSO commands

```
1 rlasso E260B A104 E253B E254B E259B E261B E262B S007 S012 S020 S022 S023 X002 X003 X003R
2 rlasso E260BBin A104 E253B E254B E259B E261B E262B S007 S012 S020 S022 S023 X002 X003 X003R
3 cvlasso E260B A104 E253B E254B E259B E261B E262B X002
4 cvlasso, lse
5 cvlasso E260BBin A104 E253B E254B E259B E261B E262B X002
6 cvlasso, lse
7 cvlasso E260B E253B E254B E259B E261B E262B X002
8 cvlasso, lse
9 cvlasso E260BBin E253B E254B E259B E261B E262B X002
10 cvlasso, lse
11 rlasso E260B E253B E254B E259B E261B E262B X002
12 rlasso E260BBin E253B E254B E259B E261B E262B X002
```

Table A1. The most relevant WVS items (version 4.0) for this study

Variable	Short description	Coding details
E260B	Information source: Mobile phone (target variable - scale form)	1-Daily, 2-Weekly, 3-Monthly, 4-Less than Monthly, 5 – Never
E260BBin	Information source: Mobile phone (target variable - binary form)	1-for E260B >=1 and <=4; 0-for A170 =5
E253B	Information source: Social media (Facebook, Twitter, etc.)	1-Daily, 2-Weekly, 3-Monthly, 4-Less than Monthly, 5 – Never
E254B	Information source: Talk with friends or colleagues	1-Daily, 2-Weekly, 3-Monthly, 4-Less than Monthly, 5 – Never
E259B	Information source: Radio news	1-Daily, 2-Weekly, 3-Monthly, 4-Less than Monthly, 5 – Never
E261B	Information source: E-mail	1-Daily, 2-Weekly, 3-Monthly, 4-Less than Monthly, 5 – Never
E262B	Information source: Internet	1-Daily, 2-Weekly, 3-Monthly, 4-Less than Monthly, 5 – Never
X002	Year of birth	values between 1886 and 2004

Source: Own findings using Stata 17

Table A2. Descriptive statistics for the most relevant WVS items considering the non-NULL condition for all

Variable	N (Obs.)	Mean	St.Dev.	Min	0.25	Median	0.75	Max
E260B	87741	2.44	1.73	1	1	1	5	5
E260BBin	87741	0.73	0.44	0	0	1	1	1
E253B	87741	2.7	1.8	1	1	2	5	5
E254B	87741	2.35	1.45	1	1	2	3	5
E259B	87741	3.1	1.69	1	1	3	5	5
E261B	87741	3.55	1.66	1	2	4	5	5
X002	87741	1975.64	16.43	1916	1963	1978	1989	2004

Source: Own calculations in Stata 17

Table A3. Various models using the most relevant WVS remaining influences

Model No.	(1)	(2)	(3)	(4)	(5)
Target Variable	E260BBin	E260BBin	E260BBin	E260B	E260B
Regression Type	Logit	Scobit	Probit	OLogit	OProbit
E253B	-0.4186***	-0.9218***	-0.2417***	0.4410***	0.2557***
	(0.0063)	(0.0548)	(0.0035)	(0.0053)	(0.0030)
E254B	-0.2651***	-0.4785***	-0.1557***	0.3117***	0.1810***
	(0.0064)	(0.0220)	(0.0038)	(0.0057)	(0.0033)

Model No.	(1)	(2)	(3)	(4)	(5)
Target Variable	**E260BBin**	**E260BBin**	**E260BBin**	**E260B**	**E260B**
Regression Type	**Logit**	**Scobit**	**Probit**	**OLogit**	**OProbit**
E259B	-0.1498***	-0.2538***	-0.0893***	0.0957***	0.0588***
	(0.0059)	(0.0137)	(0.0034)	(0.0047)	(0.0027)
E261B	-0.6341***	-1.7006***	-0.3199***	0.3603***	0.2183***
	(0.0116)	(0.1161)	(0.0054)	(0.0054)	(0.0032)
X002	0.0203***	0.0341***	0.0121***	-0.0134***	-0.0082***
	(0.0006)	(0.0015)	(0.0004)	(0.0005)	(0.0003)
_cons	-33.7885***	-50.5590***	-20.5299***		
	(1.2081)	(2.4583)	(0.7010)		
lnalpha		-1.1583***			
		(0.0650)			
cut1				-22.8815***	-14.0814***
				(0.9543)	(0.5605)
cut2				-22.1901***	-13.6788***
				(0.9544)	(0.5605)
cut3				-21.8614***	-13.4884***
				(0.9544)	(0.5606)
cut4				-21.4249***	-13.2367***
				(0.9543)	(0.5605)
N	87741	87741	87741	87741	87741
chi^2	17218.95		19397.28	30872.96	34542.18
p	0.0000		0.0000	0.0000	0.0000
R^2	0.33		0.33	0.19	0.19
AIC	67801.38	67457.53	68153.95	177927.01	177884.48
BIC	67857.67	67523.21	68210.25	178011.45	177968.92
AUC-ROC	0.87		0.87		

Source: Own calculations in Stata 17

*Notes: Robust standard errors are between round parentheses. The raw coefficients marked with *, **, and *** indicate significance at 5%, 1%, and 1‰.*

A SCIENTIFIC PERSPECTIVE ABOUT THE INTEGRATION OF SMART CITIES IN THE METAVERSE

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"Without constant pressure for theory building, the field would surely slide to its natural resting place in dust-bowl empiricism".
(Webster and Watson, 2002)

Abstract: Today's cities are more and more open to the digital transformations of society, which highlights their ubiquitous smart city character. Through a review of the specialized literature, this paper aims to identify the extent to which the scientific literature in the field deals with the integration of smart cities into the metaverse as a research subject. The results of our study within the Scopus database reveal that metaverse-related immersive technologies can assist urban environments, showcase the integration of metaverse with IoT as a support technology for smart cities, and design future smart cities. We also concluded that teleportation is used for navigating large urban immersive virtual environments and that the metaverse is constituted as a virtual form of data-driven smart urbanism and even as a virtual form of smart cities. The integration of the two domains is possible through immersive technologies such as 3D displays, interactives, and integrating digital twins or advanced intelligent technologies. Our study's originality lies in the integrated perspective of the intersection of the two fields, smart cities and metaverse, reached so far by academic research. Our results become the starting point for further studies in the field.

Keywords: metaverse; smart cities; IoT; 3D technologies; digital twin

JEL classification: O30, O33, O35, Q55

Introduction

The greatest technological changes in our lives are becoming a new reality, along with the rate of increasing returns (Kurzweil, 1999). Numerous new technologies that speed up, automate, and simplify interactions between human and non-human actors are being given the prefix "smart" (Poslad, 2011).

„Smart cities" seems to be more of a North-American term (Batty, et al., 2012), used along with others, such as intelligent cities, virtual cities, or information cities, in order to emphasize technology-based management techniques that improve the city experience and boost the productivity of city organizations and locations (Buhalis, et al., 2023).

Therefore, a smart city (National Geographic, 2023) is one that has a variety of sensors (usually hundreds or thousands) installed to gather electronic data from and about infrastructure and people in order to increase productivity and quality of life.

The metaverse, first coined by Neal Stephenson's 1992 novel Snow Crash, is an ecosystem where virtual worlds combine immersive virtual reality with physical actors, objects, interfaces, and networks in a future form of the internet (Huggett, 2020). A social virtual world parallels and replaces the real world by connecting physical devices (Park and Kim, 2022).

Metaverse, a project launched in the middle of the COVID pandemic, will continue the dematerialization of the world that the Internet began and will add new value to society (Rickli and Mantellassi, 2022).

According to a forecast study by consulting company Analysis Group (Ramage, 2022), if the Metaverse economy develops at the same rate as mobile technologies currently do, it will generate $3 trillion in GDP over the next ten years, which represents an average annual growth of 2.8%.

This is why we aim to study the integration of smart cities in the metaverse in the context of disruptive technologies. The results will contribute to the findings of similar research on the topic of innovative and disruptive technologies and their applications in the real or real virtual world and urban communities. Our originality relies on the umbrella of the intersection of these two ecosystems, smart cities and the metaverse, with an emphasis on the integration of smart cities in the metaverse.

The paper is organized as follows: section *Materials and Methods,* which provides an overview of the materials and research techniques used, and Section 2 *Results,* which presents the findings in response to the research question. The findings are covered in Section 3, *Discussion*, and summarized in the *Conclusions* section.

1. Materials and Methods

Webster and Watson (2002), two reference authors both in the field of research methodology and in the field of information systems, consider that constructing a literature review is challenging in the information systems area of research because of the variety of fields involved. Still, they become the foundation for research and are critical to strengthening IS as a field of study.

Therefore, we performed systematic research on the Scopus scientific database as a source of data because it includes the most relevant articles published in mainstream journals. We combined two keywords, meaning („smart cit*" and „metaverse"). For the first phrase, we applied the truncation technique in order to include all the expression's forms in our research. These expressions were used with the title, abstract, and keyword areas for all the types of papers: articles, conference papers, reviews, conference reviews, erratum, and sort surveys. As a results, we obtained 43 results.

Although we didn't apply any filter for time, all the papers matching the two keyword criteria and selected by the Scopus academic browsing engine software are very new, published in the short period Post-Covid from 2021 (1 open source article written in Korean), 2022 (28 documents), and 2023 (13 documents).

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology was applied within the mapping process to meaningfully and traceably omit extraneous datasets (Page, et al., 2021). PRISMA is primarily focused on reporting reviews that evaluate the outcomes of interventions, but it may also act as a foundation for reporting systematic reviews with objectives other than evaluating treatments (https://prismastatement.org, accessed on May 31, 2023).

Therefore, for the total of 43 Scopus-indexed papers above, written from 2021 to 2023, that we initially identified using the searching keys, we continued by applying several exclusions or rules:

- **1st rule (limitation to document type)**: documents such as conference papers, reviews, conference reviews, erratum, and short survey were removed, leaving 21 from 43, leaving 22 articles;
- **2nd rule (limitation to English articles)**: articles written in other languages than English were removed, meaning 1 (Korean) from 22, leaving 21 English articles;
- **3rd rule (limitation to open-source documents)**: we removed all the non-open-source articles, meaning 4 from 21. In this manner we obtained 17 open-source articles as intermediary results;
- **4th rule (limitation to relevance and other manual checks)**: we also analyzed the 17 remaining lists of Scopus articles for relevance (11 published in 2022 and 6 published in 2023), based on two personalized criteria:
  - If the „smart cit*" and „metaverse" key words were really included in the title, abstract, or keywords of each article. Thus, we removed two articles from 17, resulting in 15 articles;
  - Whether the 15 remaining documents are or are not articles, possible types of reviews or mixed types. The result is almost surprising, as from the pool of 15 articles, 6 documents are mixed or literature reviews. Thus, the final result is nine articles that combine all the above criteria.

The list with all resulting articles was saved as an Excel file and contains full records. The articles were also downloaded as PDFs and carefully reviewed. Each article's content was examined in light of the established research questions and topic classification. The following sections of the manuscript include the important ideas that were taken out of the text.

As a result of the quantitative analysis, we looked for answers to the following research question: *„How well-integrated into the metaverse are smart cities?"*.

The following section will provide arguments and answers to the above research question, based on the academic literature in the IS field and more details about the selected articles retrieved via the Scopus database.

2. Results

Prior to outlining the solutions to our research questions based on the findings of the research methodology, we give an overview of the key articles that were chosen and the major aspects of the study.

A summary was written with the intention of reading and categorizing the included papers (n = 9), allowing the most significant characteristics of the papers to be noted for later evaluations and comparisons.

1. In „3D Display and Interactive Technology in Metaverse" (Fan et al. 2022), the authors aim to find out not only the main technologies that employ 3D display and interaction social networks, but also the main pillars of the Metaverse as the accelerating factor of smart cities. The Metaverse is seen both as a physical world (AR) and as a virtual world (VR), at its intersection (XR).

Based on a multi-study case study (Kilani and Kobziev, 2016), algorithms, and quantitative research data, the focus moves on from 2D to 3D conversion algorithms, conversion and depth sensing technologies, depth information reconstruction technology based on structured light, and time of flight technology, mainly 3D technologies such as single-lens interactive, dual-lens interactive, and depth camera interactive technologies. By building the five strong pillars of the

metaverse, it will be possible to materialize them in future applications, such as smart cities. These are the 3D display and interaction, the block chain, the network, the artificial intelligence (AI), and the games that are delivered by specific technologies and platforms and help create the metaverse and the virtual smart cities.

2. In "Defensive Distillation-Based Adversarial Attack Mitigation Method for Channel Estimation Using Deep Learning Models in Next-Generation Wireless Networks" (Catak et al, 2022), a technology-based analysis of the NextG (future wireless networks) technologies, as well as the vision of the forthcoming cellular systems that connect billions of people and devices together, is presented. Their goal is to support the new applications in the Metaverse, including virtual reality (VR), virtual smart cities, and more.

3. The "Integrating Digital Twin and Advanced Intelligent Technologies to Realize the Metaverse" article (Aloqaily, et al., 2022) focuses on the Metaverse conceptual layers and AI advancements for the new applications in smart cities, health care, or education. The authors consider the metaverse an early-stage ecosystem that is developing along with disruptive technologies. The metaverse is a hybrid world of real and imitational objects (avatars) that enables the physical world to exist within the virtual world, but the virtual transactions and the virtual behavior interactions of people from virtual smart cities will impact changes in the real world.

4. In "The Metaverse as a Virtual Form of Data-Driven Smart Urbanism: On Post-Pandemic Governance through the Prism of the Logic of Surveillance Capitalism" (Bibri and Allam, 2022), intensive research focuses more on the social and economic implications of the metaverse applications in smart cities and smart urbanism than on the technological layers that enable their expansion.

The present article provides an innovative decision support system based on multi-criteria analysis centered on the metaverse as a giant ecosystem application and a virtual form of data-driven smart urbanism.

In addition, it provides a large framework that helps policymakers and users understand and assess the ramifications of the new hypothetical parallel virtual environment that incarnates ways of living in virtually inhabitable cities, where private data are more exposed to profit-making purposes by companies and public governance.

5. "The Social Shaping of the Metaverse as an Alternative to the Imaginaries of Data-Driven Smart Cities: A Study in Science, Technology, and Society" (Bibri, 2022) provides a large umbrella of concepts and technologies related to society and science, especially in metaverse and smart urbanism. At the core of the systematic exploration, the authors present a comparative analysis of the metaverse and ambient intelligence. It aims to deepen social and technological critiques and understandings of the data-driven smart cities based on the evaluation of the Metaverse, to extend the warning signals and to construct desirable alternative futures within the scope of an ethical society, acceptable and beneficial for all citizens (users).

As main key results, we find that: (1) the metaverse is speculative fiction and a techno-urban utopia based on three-layer architecture: infrastructure, interaction, and ecosystem; (2) the construct of the metaverse from speculation fiction to a socio-technical vision, as the metaverse is still more a vision of the future of reality than a reality; (3) the metaverse into a societal-urban future transforms, enriches and becomes an integral part of everything people do, so it produces the next society according to the new rules and frameworks.

6. In "Adopting metaverse-related mixed reality technologies to tackle urban development challenges: An empirical study of an Australian municipal government" (An. 2022), the author presents the City Lens project that won a national award of the Smart City Strategy Australia - the City of Wyndham, from the metropolitan area of Melbourne. The

immersive holograghic system aims to plan the urban ecosystem of the city, helped by IoT sensors and mixed reality, respectively, metaverse technologies, by adding 3D holograms to the existing environments. The new powerful tech-based, data-driven solutions develop along with the new high-rise buildings. The Whyndham City Lens application is a data-driven platform that enables digital and physical objects to interact in real-time.

Stakeholders (city councils, residents, businesses and universities) and users interact with the holographic view to switch between different data sets and 3D city models by pointing fingers towards the holographic view and selecting different layers via the interactive menu interface.

7. In “An empirical evaluation of enhanced teleportation for navigating large urban immersive virtual environments” (Shahbaz, et al., 2023), the study aims to find out the best digital applications for teleportation in the virtual smart cities, as navigation is the most relevant interaction in the metaverse of large urban environments virtual (Ves), based on two components: wayfinding and travel.

The authors conduct a lab experiment with 25 people to test three interaction apps, such as Mini-Map, Portal-View, and X-Ray Vision, within the Oregano State University (OSU), measure quantitative and qualitative variables with statistical and subjective measurements, and present the analysis of the results and scores. Thus, the metaverse is the support ecosystem of the virtual smart cities.

8. In “When Internet of Things Meets Metaverse: Convergence of Physical and Cyber Worlds” (Li, et al., 2023) the convergence of the physical and virtual worlds is studied by the main tech facilitators, meaning the IoT technologies, that apply in six areas, such as smart cities, health care, education, entertainment, real estate, and socialization.

In order to apply the IoT-empowered Metaverse, the pillar technologies are analyzed at their bases: AI, high-speed data communications, cost-effective mobile edge computing (MEC), and digital twins. They provide immersive virtual experiences as a new reality, answering the "anywhere, anytime, and any participant" requirements of the evolving metaverse.

9. “MetaOmniCity: Toward Immersive Urban Metaverse Cyberspace Using Smart City Digital Twins” (Kuru, 2023) provides a large overview of the virtual smart city MetaOmniCity application that aims to solve particular urban problems, add value in the future to the urban ecosystem and enhance the life quality of citizens. The study case systematically presents the virtual cities from the metaverse, that are digital twins of the real ones, like Seoul (Korea) or Santa Monica (California), linking highly realistic immersive experiences with rich urban activities using numerous metaverse tools and utilities. Local governments of such cities build metaverse plans to transform their SC apps into metaverse environments, but there is no representative initiative for a comprehensive urban metaverse space development, that MetaOmniCity aims to solve, along with proposing identifiable, agreed-upon guidelines.

As for the year of the publication we have noticed the novelty of the combination of the two keywords (6 articles in 2022 and 3 articles in 2023, up to May 31, 2023), although these distinct research areas are analyzed from earlier stages of time.

The result of the research question is shown below.

3. Discussion

Therefore, through a summary of the analyzed articles, we can provide the answer to the research question below.

As depicted above, we can highlight the integration level of smart cities in the metaverse. Prior to this, we forsaw that the relationship between smart cities and the metaverse would be in both directions due to the evolving and growing technologies. Metaverse-related immersive

technologies can assist and enrich real urban environments and cities with extended cyber layers, showcase the integration of the metaverse with IoT as a support technology, and design future smart cities. On the other hand, the metaverse ecosystem, based on information system programming algorithms that integrates virtual activities, interactions and locations become the digital twin environment for cyber data-driven smart urban cities and countries domains. The real life and society is mirrored in the metaverse smart cities, that adds new activities and behaviors that become independent from the physical world. New digital values are transacted and evaluated by new means in the new economy of virtual smart cities.

Still, the real smart cities increase the extended reality approach with the data-driven sensor tools that add new virtual layers to urban life. At the same time as the disruptive technologies and the capacities of the virtual devices develop, the smart cities tend to integrate more into the virtual world and become new digital twins of the real cities, with virtual locations, infrastructure, interactions (such as teleportation), and activities. In this aspect, the new smart cities of the metaverse add a social, economic, and cultural virtual world that parallels, and in some aspects, replaces the real world (Mason, 2015).

The emerging integration of smart cities in the metaverse becomes the source and reason for future developments due to disruptive technologies such as artificial intelligence (AI) and analytics, block chain, 6G and networking, and 3D displays, along with the metaverse equipment, as the edge computing area. Researchers need to grasp and find solutions to problems such as the persistence, uniqueness, and universality of urban users' presence in the metaverse.

Although the integration of the smart cities in the metaverse arises concerns and warning signals that never existed before, they become the source of human progress and social changes. This is why the academic research need to review, focus and develop desirable alternative futures for the scope of an ethical society, acceptable and beneficial for all citizens (uses) (Bibri, 2022)**.**

Conclusions

The current research revealed that the academic literature on behalf of the intersection of the two concepts „smart cit*" and „metaverse" is relatively new, as reflected in the dates of the articles selected for our systematic review. Nice selected articles provide a general perspective on the novelty of the research theme and can be tracked as a post-Covid era result. In accordance with different studies on disruptive technologies, the focus on the emerging integration of smart cities in the metaverse raises the potential for further developments and studies in order to develop integrated applications, prevent warning signals, and find new emerging beneficial tracks for humankind.

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SMART CITIES RESEARCH IN EUROPE: EXPLORING THE POWER OF ALGORITHMS

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Abstract: In the last decade, the European countries witnessed significant progress in the implementation of smart city initiatives, where, based on the specialized literature, the topic of algorithms is of outmost importance for achieving sustainability and efficiency goal in relation to smart city initiatives. The current article aims to perform a review to examine the diverse applications of algorithms in European smart cities, covering areas such as intelligent transportation systems (ITS), energy management (EM), waste management (WM), citizen engagement (CE), and urban planning (UP). The review presents the identified key algorithms approaches, data analytics techniques, and the integration of emerging technologies in the context of European smart cities. Furthermore, it provides important insights on the ethical implications of algorithmic based decision-making and displays the urge for transparency and accountability. Within the results, the paper consolidates the current state-of-the-art, identify gaps, and provide recommendations for future research and development in algorithmic solutions of smart cities initiatives and development with an emphasis on the European Union particularities.

Keywords: European Smart cities; Algorithms; Intelligent transportation systems; Energy management; Waste management; Citizen engagement; Urban planning

JEL classification: M15, O33, O52

Introduction

In the ever-evolving landscape of modern cities, the concept of smart cities has emerged as a transformative force, driving the vision of intelligent, sustainable, and efficient urban development. Among the regions that have made remarkable strides in this groundbreaking movement is the European Union, where significant progress in smart city initiatives has been witnessed (Pica, 2019) (Tahir, et al., 2023) (Stolfi, 2018) (Anedda, 2021). At the heart of these forward-thinking initiatives lies the integration of cutting-edge technologies, with algorithms emerging as a fundamental tool to realize sustainability and efficiency goals in European smart cities (Convertini, 2018) (Papadimitriou, et al., 2019).

The strategic implementation of algorithms has become a cornerstone in the dynamic landscape of smart cities, empowering urban centers to harness the vast potential of data-driven decision-making. From intelligent transportation systems that optimize traffic flow (Volker, et al., 2018) and energy management platforms that reduce consumption (Masek, et al., 2016), (Volker, et al., 2018) to waste management systems that promote sustainability (Stolfi, 2018) and citizen

engagement platforms that foster interaction and participation (Bettencourt, 2021), algorithms play a pivotal role in driving innovation and enhancing the quality of life for citizens.

This review article embarks on an illuminating journey through the diverse and pivotal applications of algorithms within European smart cities, exploring a wide array of domains and use cases (Rauniyar, et al., 2022). It encompasses ITS, that streamline mobility and reduce congestion (Djahel, et al., 2015), energy management platforms that optimize resource consumption and promote sustainability (Masek, et al., 2016), and waste management systems that enable efficient recycling and waste disposal (Stolfi, 2018). Moreover, it examines citizen engagement platforms that foster interaction and participation (Bettencourt, 2021), and urban planning frameworks that optimize resource allocation and infrastructure development (Pica, 2019).

With a keen focus on data analytics techniques and the integration of emerging technologies, this manuscript aims to consolidate the current state-of-the-art in algorithmic solutions for smart cities in the European Union. It highlights the ethical implications of algorithmic decision-making (Fernández, 2013), emphasizing the need for transparency, accountability, and responsible governance in implementing these cutting-edge technologies (Bilotta, 2020), (Savvopoulos, et al., 2020). As we unravel the successes and challenges of algorithm applications in European smart cities, this review endeavors to identify gaps and provide recommendations for future research and development, laying the groundwork for a sustainable and technologically advanced urban landscape in the European Union.

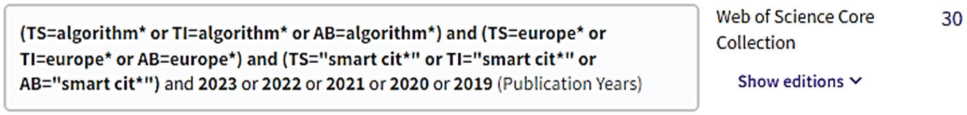

Figure 1: Keywords, Query syntax and the number of results

The research methodology for this paper includes 27 papers based on systematic search using reputable academic database, Web of Science (WOS), as it can be depicted from Figure 1. Relevant articles were identified using keywords related to smart cities, algorithms, and the European context, within the titles (TI), topics (TS) and abstract (AB) within the WOS database. Further, the screening process focused on aligning the studies with the scope of the research, revealing algorithms applications in European smart cities across various domains. Through this robust methodology, a comprehensive and diverse set of papers was curated, offering valuable insights into the role of algorithms in advancing smart cities in Europe.

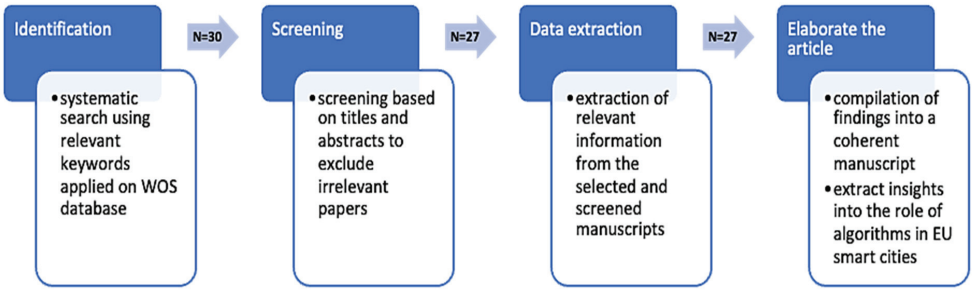

Figure 2: Research methodology

Consequently, as presented on Figure 2, 30 manuscripts were identified and after screening them, 3 were removed. The remaining 27 articles were fully read and the data extraction process followed a structured approach, focusing on the algorithms and the sectors of smart cities analyzed and included in the selected manuscripts.

1. Understanding Algorithms in Smart Cities

In the context of Smart Cities, algorithms are of paramount importance, serving as the backbone that drives data-driven decision-making, efficiency, and sustainability. These complex mathematical and computational tools empower Smart City systems to collect, analyze, and interpret vast amounts of data generated by sensors, IoT devices, and citizens, facilitating real-time responses and informed urban management.

1.1. Data Processing and Analysis

Revealed throughout literature review as one of the primary functions of algorithms usage within Smart City systems is *data processing and analysis*. Due to the proliferation of sensors and IoT devices throughout urban environments, huge volumes of data are continuously being generated. Due to that, algorithms are critical for understanding this data, extracting relevant patterns, and obtaining proper insights. Few examples are enumerated below:

- in ITS, algorithms process data from various sources, such as traffic cameras and GPS devices, to identify traffic patterns, detect congestion, and optimize traffic flow (Stolfi, 2014)
- in waste management, algorithms analyze data from waste sensors to optimize waste collection routes and improve recycling efforts (Djahel, et al., 2015).

Through data processing and analysis, algorithms enable Smart Cities to enforce the potential of big data, driving efficiency and enhance the decision-making process.

1.2. Optimization and Resource Management

Smart Cities strive to optimize resource allocation and management to achieve sustainability and efficiency goals. Algorithms play a pivotal role in this aspect by providing optimization techniques and intelligent resource allocation strategies. For energy management, the articles analyzed reveal that algorithms are used to:

- optimize energy distribution in smart grids
- ensure that energy supply matches demand in real-time (Christopoulos, 2018).

Algorithms consider factors such as patterns for energy consumption, renewable energy availability, and weather forecasts for the purpose of assisting in optimal decisions process for energy distribution (Christopoulos, 2018). Moreover, algorithms improve the traffic signal timings in the endeavor of reducing congestions and fuel consumption, contributing to a higher urban mobility (Masek, et al., 2016). Algorithms help Smart Cities minimize waste, reduce costs, and promote sustainability as they optimize process of resource allocation.

1.3. Real-Time Decision-Making

The urban environments are described as having a dynamic nature and thus, they necessitate real-time decision-making to be able to promptly react to specific conditions and events within smart cities. Algorithms enable real-time processing of data and facilitate automated decision-making. Within public safety and security, the algorithms allow to process data using as input video surveillance and social media data. The aim is to detect anomalies and identify potential

threats in order to be able to alert authorities (Anedda, 2021). Besides public safety and security, real-time decision-making is also crucial in ITS, where algorithms improve traffic signals to respond to changing traffic conditions and, thus, mitigate congestions and improve traffic flow (Stolfi, 2014). When automating decision-making processes, algorithms improve the responsiveness and effectiveness of Smart City systems.

1.4. Personalization and Citizen Engagement

Citizens are of most importance in Smart Cities, and due to that, algorithms enhance citizen engagement while allowing them to access personalized services. Studies show that algorithms can provide tailored recommendations and services (Tahir, et al., 2023) by analyzing data that refers to citizens' preferences, based on their feedback, and behaviors. Some authors (Convertini, 2018) reveal that citizen engagement platforms mostly use recommendation algorithms to personalize citizen's suggestions for public events, services, and activities according with their individual interests. Moreover, the algorithms that use sentiment analysis can help city managers understand public opinion on various issues and also to enable them to better comprehend citizen needs and perform various types of decisions involving data-driven (Tahir, et al., 2023) technique. Personalization through algorithms fosters a sense of belonging and active participation among citizens, ultimately leading to a more engaged and satisfied urban population.

In the light of the above, it can be stated that algorithms can be seen as the cornerstone of Smart Cites, as they facilitate data processing, lead to optimization, support the real-time decision-making, and enhance citizen engagement (Convertini, 2018). They enable cities to harness the power of data and emerging technologies to tackle urban challenges, promote sustainability, and enhance the overall quality of life for citizens. In the next years, Smart Cities will evolve and embrace new technologies and, thus, algorithms will continue to play an essential role in shaping the future urban landscape.

2. Key Applications of Algorithms in European Smart Cities by sectors of activity

The analyzed manuscript reveal that algorithms have a transformative impact (Convertini, 2018) in the advancement and success of transforming the European Smart Cities. Smart cities take advantage of digital technologies to improve urban living. Consequently, algorithms offer powerful tools for processing big amounts of data, providing informed decisions, and optimizing different aspects of citizen's life. We aim to examine in this section the plethora of algorithms usage within European Smart Cities, by covering the key domains as they were extracted from the selected articles, such as ITS, energy management, waste management, citizen engagement, and urban planning.

2.1. Intelligent Transportation Systems (ITS)

According with the specialized literature, an important applicative area of algorithms in Smart Cities lays in the domain of ITS. It is known that traffic congestion represents an important urban issue, and algorithms prove to offer viable solutions (Noskov, 2018), (Stolfi, 2014). Using algorithms for the management of traffic requires real-time data from various sources, such as GPS devices, sensors, and video cameras for the purpose of optimizing traffic flow, eliminating congestion, generate end-to-end routes for wheelchair users (Gani, et al., 2019) and increasing overall mobility (Stolfi, 2018), (Djahel, et al., 2015). Algorithms' usage dynamically improves city traffic (Christopoulos, 2018) by offering alternative routes due to real-time updates transmitted to drivers, public transportation users and even pedestrians. The analysis of historical data and current traffic conditions, ITS algorithms can forecast traffic patterns,

plan routes in an efficient manner, and brings essential contribution to reduced travel times and, thus, to fuel consumption (Stolfi, 2018).

2.2. Energy Management (EM)

Efficient EM is an essential aspect (Christopoulos, 2018) for a sustainable Smart City. In this area, algorithms use are beneficial to optimizing energy consumption, facilitates distribution chains, and are conducive to reducing the greenhouse gas emissions by enhance energy efficiency (Pica, 2019). Smart grid algorithms enable dynamic energy distribution, matching energy supply with demand in real-time (Christopoulos, 2018). Moreover, algorithms are applied to predict energy consumption patterns (Savvopoulos, et al., 2020), allowing better planning and utilization of renewable energy sources (Christopoulos, 2018). EM algorithms are also known (Bilotta, 2020) for optimizing the functionality of smart buildings, adjusting heating, cooling, and lighting systems based on occupancy and external conditions, leading to energy savings (Savvopoulos, et al., 2020).

2.3. Waste Management (WM)

Algorithms have revolutionized WM practices in the context of Smart Cities (Djahel, et al., 2015) (Christopoulos, 2018). Thus, with the integration of sensors and data analytics, the application of algorithms within the waste collection facilitates the optimization of waste collection routes, reducing fuel consumption and lowering the carbon footprint (Stolfi, 2018). These algorithms include factors like waste generation patterns, population density, and traffic conditions to schedule collection routes in an efficient way (Christopoulos, 2018). Additionally, waste sorting algorithms help the automation of recycling processes by identifying and separating different types of recyclable materials, enhancing the effectiveness of waste recycling programs (Stolfi, 2018).

2.4. Citizen Engagement (CE)

Algorithms have exerted a significant impact on CE (Noskov, 2018), (Zhang, 2020), (Anedda, 2021), (Fernández, 2013), (Jara, 2019) in relation with Smart Cities domain and enables personalized services and participatory decision-making (Tahir, et al., 2023). The CE platforms make use of recommendation algorithms for tailoring services and information provided to citizen individual preferences and needs (Convertini, 2018) (Pica, 2019). Specialized platforms leverage data from citizens' interactions, especially from social media (Papadimitriou, et al., 2019), feedback, and historical behavior to provide customized recommendations for public services, events, and activities (Convertini, 2018), (Zhang, 2020), (Jara, 2019). Moreover, sentiment analysis algorithms (Papadimitriou, et al., 2019) instrument public opinion on various urban problems and deliver it to policymakers in their endeavor to better understand citizens' needs and be able to make data-driven decisions (Tahir, et al., 2023).

2.5. Urban Planning (UP)

UP algorithms essentially contribute to the efficiency of design and development within the realm of Smart Cities (Pica, 2019), (Rauniyar, et al., 2022), (Djahel, et al., 2015), (Masek, et al., 2016), (Bettencourt, 2021). City specialists in UP use algorithms to simulate various scenarios, assess the impact of new infrastructure projects, and optimize land use (Anedda, 2021). For instance, urban growth prediction algorithms can forecast population growth and spatial development, aiding in long-term urban planning (Papadimitriou, et al., 2019). Furthermore, algorithms support the design of sustainable and pedestrian-friendly urban spaces by optimizing the placement of parks, transportation hubs, and amenities (Bettencourt, 2021).

In the last years, algorithms are the backbone of the development of Smart Cities, offering innovative solutions to complex urban challenges (Convertini, 2018). Their applications in ITS (Stolfi, 2014) (Stolfi, 2018) (Christopoulos, 2018), EM (Christopoulos, 2018) (Savvopoulos, et al., 2020), WM (Stolfi, 2018) (Christopoulos, 2018), CE (Pica, 2019) (Noskov, 2018) (Papadimitriou, et al., 2019) (Zhang, 2020), and UP (Rauniyar, et al., 2022) (Djahel, et al., 2015) (Papadimitriou, et al., 2019) (Masek, et al., 2016) have significantly enhanced the quality of life for citizens (Djahel, et al., 2015) and public institutions. Due to the advances of technology and data availability, the algorithms will continue to be of outmost importance in the process of transforming cities into sustainable, efficient, and citizen-centric urban environments (Convertini, 2018).

3. Benefits and Challenges of Algorithm Adoption

Algorithm's adoption in Smart Cities domain, offers numerous benefits that enhance urban and citizen well-being. Among the significant advantages we found improved data-driven decision-making. Thus, algorithms enable the processing and analysis of big data from various sources, such as public video cameras, sensors, social media, and citizen feedback. This data-driven approach empowers city governance to gain valuable insights into urban latest discoveries, identify traffic patterns, minimize energy consumption, and others. Improving the process of making informed decisions based on relevant and up-to-date data, Smart Cities optimize resource allocation, minimize waste, and effectively address urban problems.

A notable key benefit brought by algorithms consists in the optimization of city services and public infrastructure. Therefore, algorithms enable the optimization of various aspects of urban life, like transportation, waste management, and energy distribution. In ITS, algorithms optimize traffic signal timings to reduce congestion and enhance mobility (Stolfi, 2014). In waste management, algorithms optimize waste collection routes, leading to more efficient waste disposal and recycling efforts (Djahel, et al., 2015). Moreover, algorithms use in EM facilitate smart grid optimization, matches energy supply with demand, and integrates renewable energy sources (Christopoulos, 2018). These optimization efforts contribute to resource efficiency, minimization of costs, and environmental sustainability in Smart Cities.

Apart from the numerous benefits, the adoption of algorithms in Smart Cities bring several challenges that need to be carefully addressed. Among the primary challenges we mention ethics, data privacy and security because Smart Cities presumably collect and analyze vast amounts of data, including sensitive information about citizens. Ensuring the privacy and security of such data is crucial to maintain public trust. City governance must implement strong data protection measures, reliable encryption, and access controls to safeguard citizen data from either unauthorized access or misuse.

The ethical implication of algorithmic decision-making is a very important challenge. And this mainly because algorithms can inadvertently perpetuate bias or apply discrimination if not carefully designed and monitored. For example, in ITM sector, algorithms may prioritize certain routes, and this may lead to inequitable distribution of resources. City architects and algorithm developers must enforce the fairness, transparency, and accountability in algorithmic applications. Regular audits and evaluations are essential to identify and rectify any biases that may arise from algorithmic decision-making process.

The complexity of algorithm implementation and integration into existing city infrastructure also bring technical challenges. The development and deployment algorithms require experts in data science, machine learning, and software engineering. Further, the integration of algorithms into diverse city systems and ensuring their interoperability can be an overwhelming process. Smart Cities responsible must invest in skilled personnel and robust technical

infrastructure to overcome these challenges and harness the full potential of algorithms for urban development.

Conclusions

Algorithms hold immense significance in the development of smart cities across Europe, offering multifaceted benefits and addressing numerous challenges. These computational tools are crucial in optimizing various aspects of urban life, such as transportation, EM, WM, CE, and UP. Through real-time data analysis and decision-making, algorithms contribute to more efficient traffic flow, reduced congestion, and enhanced mobility in ITS. They facilitate the integration of renewable energy sources, ensuring sustainable EM and a resilient power grid. Additionally, algorithms assist in WM by optimizing waste collection routes and promoting recycling efforts, leading to a cleaner and environmentally friendly urban environment. They also play a pivotal role in CE, providing personalized services and enhancing the overall urban experience (Convertini, 2018) (Noskov, 2018) (Zhang, 2020).

Table 1 provides a Smart cities domain overview together with the types of techniques/algorithms (second column) identified in the literature review (N=27) within the European smart cities. The sectors (first column) mainly display areas like urban mobility, governance citizen services (public services), energy management, and waste management.

Table 1 displays a diverse range of techniques and algorithms employed to address the particular challenges faced by smart cities in Europe that aim to be become a green and sustainable environment.

Table 1. Techniques/algorithms usage across different sectors of European Smart Cities

Sector of Smart City (in EU)	Types of Techniques/Algorithms Used
Energy Efficient & Green Buildings	Clustering for Load Energy Profiling (Savvopoulos, et al., 2020)
Envinron-urban and techno-economic	IoT-based real-time noise and emissions monitoring (Rauniyar, et al., 2022)
	Fuzzy Logic (Christopoulos,2018)
Governance Citizen Services	Hybrid recommender system (Convertini, 2018)
	Urban responsive design, Protocol's dynamic framework (Pica, 2019)
	Canny edge detection algorithm (Noskov, 2018)
	TraffictYpe-based DifferEntiated Reputation algorithm (Anedda, 2021)
	Clustering Algorithms (Fernández, 2013)
	WheelShare (machine learning classification algorithm) (Gani, et al., 2019)
	Snap4City (Badii, et al., 2020)
	Association mining (Moretto, et al., 2022)
	GEO-TRUST (Jara, 2019)
	Dijkstra's algorithm, A* algorithm (Bettencourt, 2021)
Public Information	GEO-TRUST (Jara, 2019)
	Latent Dirichlet Allocation, K-Means, SVM, DCNN (Andrade, 2020)
	Proof of Offset (POO) (Sabbatini, 2021)
	Traffic Flow Reconstruction, Traffic Distribution Matrices (Bilotta, 2020)
	Random Forests algorithm, SVM, Deep Neural Networks (Hadjidimitriou, 2019)
	UnCrowdTPG (Gustarini, et al., 2014)
	Dijkstra's algorithm, A* algorithm (Bettencourt, 2021)
Smart mobility, gas emissions	Evolutionary Algorithm, Rerouting Algorithm (Stolfi, 2014)

Sector of Smart City (in EU)	Types of Techniques/Algorithms Used
Urban mobility	Data Fusion, Processing, and Aggregation Techniques (Djahel, et al., 2015)
	Dynamic neighborhood estimation algorithms (Papadimitriou, et al., 2019)
	Genetic algorithm (Masek, et al., 2016)
	Diffie–Hellman key exchange algorithm, SHA256 hash algorithm (Tahir, et al., 2023)
	Clustering Algorithm (Volker, et al., 2018)
	TOSCA, DITRAS, MyWay, RAMA, EPOS (Andrienko, et al., 2021)
	Traffic Flow Reconstruction, Traffic Distribution Matrices (Bilotta, 2020)
	Random Forests algorithm, SVM, Deep Neural Networks (Hadjidimitriou, 2019)
	UnCrowdTPG (Gustarini, et al., 2014)
Waste Management	Eco-friendly Route Algorithm, Green Algorithm (Stolfi, 2018)
Wireless Communications and Mobile Computing	Improved Dijkstra Routing, SDN-Based Disjoint Routing (Zhang, 2020)

From machine learning algorithms like clustering, classification, and support vector machines to data fusion and processing techniques, the algorithms presented in Table 1 prove that they play a vital role in pursuing the smart city initiatives. Each article analyzed bring a valuable insights and solutions that cater to specific urban challenges, highlighting the growing implication of algorithm's usage in shaping the development and sustainability of smart cities across Europe.

In conclusion, with the vast benefits brought by Smart cities, come challenges that need careful consideration. Aspects like ethics, data privacy and security are vital, because the huge amount of sensitive data collected in smart cities involves strong security measures. Ethical issue in connection with the use of algorithmic based decision need to be considered for avoiding biased outcomes and ensure objectivity in city services. Moreover, algorithms implementation and integration within the existing urban systems has a high degree of technical complexity and involves skilled experts and careful planning. By raising the awareness and spotting the potential of algorithms while carefully addressing its challenges, European smart cities can harness the full potential of these tools, generating green, sustainable, efficient, and human-centered urban environments for their citizens.

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SECTION 3

SMART CITIES AND COMMUNITIES: INVOLVED STRATEGIES, SMART EDUCATION AND LEARNING ENVIRONMENTS

GERMAN SMART CITIES AND THEIR STRATEGY: EMPIRICAL INSIGHTS

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Abstract: More and more smart cities are emerging in response to increasing urbanization and the need for sustainable and efficient urban development. These cities leverage advanced technologies and data-driven approaches to enhance various aspects of urban life, including transportation, energy management, public safety, and citizen engagement. The consequence of this increasing digitization is the collection, storage, analysis, and sharing of large amounts of data. Recent developments in sustainable urban development have increased the need for effective data strategy and governance to maximize the value of data-driven approaches, and therefore data. In this regard, data strategy and governance must be an integrative part of a digitization (or smart city) strategy. Evidence-based research on this topic is scarce in this regard because much research focusing on a literature-based approach to conceptualization. This study aims to fill such a research gap and examines the current state of strategy initiatives in smart cities in Germany. Using online content analysis, a checklist, and a coding scheme, we sought to obtain empirical evidence of strategy initiatives related to digitization, data, and governance, as well as their transparency and progress, on a sample of 82 major German cities (state capitals of the 16 German states and cities with at least 100,000 inhabitants). Preliminary results show varying degrees of sophistication and transparency of strategy initiatives. These results provide insights into possible directions of the development of strategy initiatives in smart cities.

Keywords: Strategy; Digitalization; Data Governance; Content Analysis; Interpretive paradigm

JEL Classification: R11, R12, R58

Introduction

Advancing digitalization is forcing cities and municipalities to embrace the digital transformation, i.e. to be smart, and to make use of the associated opportunities. The challenge here is to shape digitalization strategically and with the common good in mind in terms of sustainable and integrated urban development (WBGU, 2019). Being smart means using modern information technologies (IT) to optimize the use of resources and to manage cities more efficiently. This change needs goals, strategies, and structures to be successful. At the beginning, there is the digitalization digitization strategy as a framework (BBSR, 2022), from which a data strategy must be developed in the further course in order to ensure the secure handling of the new and sometimes sensitive data created by digitalization (BBSR, 2022). This data strategy is ultimately controlled by data governance, a concept for defining internal

standards or data guidelines for the collection, storage, processing, and destruction of data (Weber and Klingenberg, 2021). This study examines the current state of strategy initiatives in cities in Germany. Using an online content analysis, a coding scheme and a checklist, it sought to obtain empirical evidence of strategy initiatives related to digitization, data and governance, as well as their transparency and progress in a sample of 82 German cities (16 state capitals and 66 large cities, i.e. with at least 100,000 inhabitants).

1. Theoretical Background

In this section, the relevant concepts are introduced. For this purpose, the authors have developed a framework (Figure 1) in which the relevant concepts are placed in context:

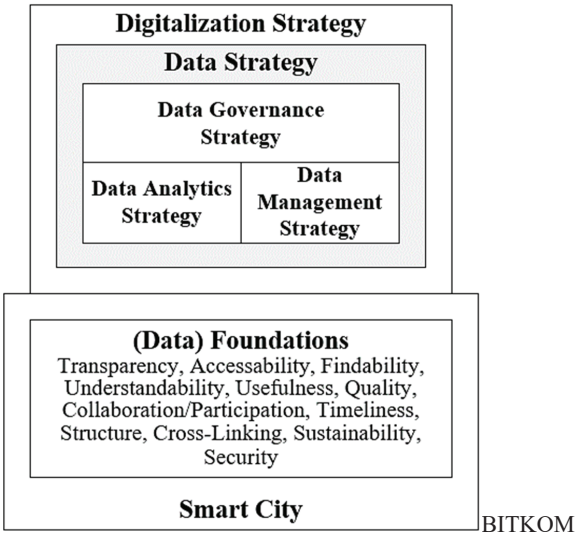

Figure 1: Framework

Source: Authors' contribution

Smart city concept: Smart city describes an (intelligent, clever, smart or clever) concept of a city in which modern (information and communication) technologies, ICT, are supposed to solve very different problems in urban development in the areas of economy, people, governance, mobility, environment and living (Giffinger, et al., 2007). These areas generate large amounts of data (Caputo, et al., 2019), the processing of which must follow the principles of transparency, accessibility, findability, understandability, usefulness, quality, collaboration/participation, timeliness, structure, interconnectivity, sustainability and security (Lnenicka, et al., 2022). In this context, the digitalization of cities and municipalities is no longer a purely voluntary task, but is made mandatory in Germany by legal standards and guidelines, e.g. "Act to promote electronic government (E-Government-Act - EgovG)" (FMoJ, 2023).

Digitization and strategy: Research distinguishes between a range of different strategies, e.g. corporate strategies, IT strategies (Bharadwaj, et al., 2013; Chen, et al., 2010; Mithas, et al., 2013). Closely following the smart city concept, for this study we agree with Schallmo et al. (2018) that a digital strategy summarizes the goals, policies and controlling structures of digital transformation processes in cities and municipalities and serves as an interface to coordinate

the numerous digitalization activities by including a digital vision and expressing the goals and priorities of the corporate strategy through digital plans.

Data and strategy: Digital activities generate a lot of data, so smart cities also must consider why and for what purpose they want to use data. Due to their special characteristics, data need special treatment (Merkus, et al., 2019), a data strategy. Strictly derived from the digitalization strategy, in this study we follow Medeiros and Maçada (2020) and DalleMule and Davenport (2017), according to which a data strategy summarizes activities related to the organization, management, analysis and use of data in a smart city. It consists of the three pillars of (a) data governance strategy, which focuses on tasks (processes) and task owners (people, machines) within the smart city organization, (b) data analytics strategy, which focuses on data and technologies to analyze and present (smart city) data, taking into account data governance policies, and (c) data management strategy, which focuses on data and technologies to organize (smart city) data for all stakeholders.

Data governance and strategy: The concept of Data Governance is inconsistent in the literature (Jagals, et al., 2021). Initially seen as an evolution of IT governance, this research area became independent as business intelligence and analytics, data management, data quality, Big Data, cloud computing, and privacy and security became more important. For this study, the MDM Institute provides a useful definition of Data Governance as "*... the formal orchestration of people, process, and technology to enable an organization to leverage data as an enterprise asset*." (MDM Institute, 2016). According to Khatri and Brown (2010), Data Governance encompasses several decision domains, including data quality, data principles, metadata, data access and data lifecycle.

2. Methods and Materials

Our study is based on an *interpretative paradigm* (Alvesson and Sköldberg, 2010) with a focus on a *qualitative study* in which content analysis (Früh, 2007) was conducted in the context of official presences of the sample (82 German cities) on the internet (i.e. publicly accessible information).

Online content analysis (or *web content analysis*) is a sub-category of the general methodology of content analysis (Früh, 2007). The focus is no longer on books or magazines (physical media), but on internet-based content (virtual medium) with its special characteristics: it changes over time in terms of appearance, structure as well as content.

This study explores the following questions: What is the current status of strategy initiatives in German cities? Are German smart cities taking into account the special importance of data as "footprints of digital action" (is there a data strategy)? Is a data governance strategy being addressed or on which fields of action of data governance is the focus?

82 German cities (66 large cities and 16 state capitals) were included in the sample for this study (see Appendix, Table 1). The identification of this sample is based on the Smart City Index (bitkom, 2022), the digital ranking for Germany's 81 major cities, plus Schwerin, the state capital of Mecklenburg Western Pomerania, which is not included in the Smart City Index due to its population (is below 100,000 inhabitants). Each of the 82 cities' websites examined was searched for information on their digitalization and smart city practices as defined by the above framework.

The following search string was applied to the online content (websites): "strategy" OR "digitalization" OR "digitalization strategy" OR "smart city" OR "smart city strategy". The search period was the end of May 2023. The presence of online information published by each city has been interpreted as an indicator of their progress or awareness of smart city and digitalization (including strategy initiatives).

The first part of the evaluation process was to check whether the cities in the sample have a digitization strategy and whether it is publicly available (count discrete: yes or no). It was expected as an expression of transparency that the cities, if they have one, make their strategy public by making it available for download on their websites. Publicly accessible strategy documents/information were then examined for information on the role of data, data strategy and data governance (discrete count: yes or no). Expanding on the topic of data governance, a checklist (Table 1) was further developed, whose criteria were derived from the scientific literature (Khatri and Brown, 2010; Otto, 2011; Koltay, 2016; Brous, et al., 2016) and are suitable for the smart city context.

Table 1. Data Governance

No.	Property	Description
1	Data Security	Statements on information security / cyber security
2	Data Privacy	Statements on privacy for sensitive (personal) data
3	Data Literacy	Statements about roles and responsibilities (including competencies, sovereignty) in handling data (ability to collect, manage, evaluate, and apply data in a critical way).
4	Data Ethics	Statements evaluating data practices that have the potential to negatively impact people and society
5	Data Quality	Statements on the treatment of data in terms of accuracy, completeness, validity, consistency, uniqueness, timeliness, and usefulness.
6	Metadata	Statements on the structure and methodology for documenting and maintaining data
7	Data Stewardship	Formalization of data management and responsibilities for

Source: Contribution by the authors

Overlaps of the criteria were minimized in order to be able to apply them to the online information of the sample.

3. (Preliminary) Findings

Every effort was made to find publicly accessible information on strategy initiatives around the topic of Smart City - on the websites of the 82 major German cities and/or state capitals. Inaccessible information on these websites, as well as study-relevant information on websites other than those mentioned, was marked as "not available" in the evaluation. Information was not explicitly requested. The (preliminary) results of the study are presented below.

3.1. Digitalization Strategy

The 82 German cities in the sample (Appendix, Table A1) were analyzed to determine whether a digitalization strategy exists or is planned, or whether a concrete project has been launched to this end. Based on the available online information, we determined the following results:

- *No information available* (29 cities, 35.4% of the sample), Table A1, No: [2], [5], [8], [11], [12], [15], [18], [19], [23], [26], [27], [40], [42], [44], [46], [48], [49], [52], [54], [57], [60], [63], [66], [69], [70], [72], [73], [77], [79].
- *Digitalization strategy project planned* (5 cities, 6.1% of the sample), Table A1, No: [36], [37], [45], [67], [71].
- *Ongoing digitalization strategy project* (4 cities, 4.9% of the sample), Table A1, No: [25], [28], [59], [65].

- *Digitalization Strategy paper published* (44 cities, 53.7% of the sample), Table A1, No. : [1], [3], [4], [6], [7], [9], [10], [13], [14], [16], [17], [20], [21], [22], [24], [29], [30], [31], [32], [33], [34], [35], [38], [39], [41], [43], [47], [50], [51], [53], [55], [56], [58], [61], [62], [64], [68], [74], [75], [76], [78], [80], [81], [82].

One explanation for the rather low proportion of published digitalization strategies is the municipal decision-making process in Germany, i.e. the interaction of municipal decision-makers in the local political-administrative system (council, administration, mayor).

3.2. Data Strategy

The 44 German cities (Appendix, Table A1) with a published digitalization strategy were also examined to determine whether they had a data strategy in place or planned, or whether a concrete project had been launched to this end. Based on the available online information, we determined the following results:

- *No information available* (31 cities, 70.5% of all cities with published digitalization strategy), Table A1, No: [1], [3], [4], [9], [10], [16], [17], [20], [21], [22], [24], [29], [30], [31], [33], [34], [35], [38], [41], [43], [50], [51], [55], [56], [58], [62], [64], [68], [74], [75], [76].
- *Topic "Data Strategy" named, but without further information* (4 cities, 9.1% of all cities with published digitalization strategy), Table A1, No: [7], [14], [39], [47].
- *Data Strategy project planned* (5 cities, 11.4% of all cities with published digitalization strategy), Table A1, No: [6], [53], [61], [81], [82].
- *Ongoing Data Strategy project* (1 city, 2.3% of all cities with published digitalization strategy), Table A1, No: [80].
- *Data Strategy paper published* (3 cities, 6.8% of all cities with published digitalization strategy), Table A1, No: [13], [32], [78].

From these results it can be deduced that only few cities have a concrete (process) plan describing how a smart city can use its data in the most profitable way in terms of strategic business objectives. Nonetheless, the published information includes references to requirements, procedures and technologies for collecting and applying the data, as well as governance and security structures that ensure responsible and ethically correct data use.

3.3. Data Governance Strategy

The 44 German cities (Appendix, Table A1) with a published digitalization strategy were also examined to determine whether a data governance strategy exists or is planned, or whether a concrete project has been launched to this end. We also investigated which data governance fields of action are generally addressed. Based on the available online information, we determined the following results:

- *No information available* (30 cities, 68.2% of all cities with published digitalization strategy), Table A1, No: [3], [9], [10], [13], [16], [17], [20], [21], [22], [24], [30], [31], [33], [34], [35], [38], [39], [41], [43], [51], [56], [58], [61], [62], [64], [68], [74], [75], [76], [82].
- *Topic "Data Governance Strategy" named, but without further information* (7 cities, 15.9% of all cities with published digitalization strategy), Table A1, No: [1], [7], [29], [32], [47], [55], [79].

- *Data Governance Strategy project planned* (5 cities, 11.4% of all cities with published digitalization strategy), Table A1, No: [6], [14], [50], [53], [81].
- *Ongoing Data Governance Strategy project* (1 city, 2.3% of all cities with published digitalization strategy), Table A1, No: [4].
- *Data Governance Strategy paper published* (1 city, 2.3% of all cities with published digitalization strategy), Table A1, No: [78].

Again, the results show that there is a lack of a concrete (procedural) plans for data governance among the cities surveyed, describing how to put a data strategy into a lived framework. During the data collection, however, we noticed that in the accessible information - despite the lack of a few concrete data governance strategies - fields of action for data governance were addressed. Based on this, we created a checklist (Table 1) to differentiate the information in this respect. In the following data analysis (Table 2), each count is discrete, i.e. the checklist was given a score of one or zero in order to be able to make a statement about the content of the web pages.

Table 2. Data Governance Checklist

Data Governance Field of Action	Count	Share
(IT-/Information-/Data-) SECURITY	37	84,0 %
(Information-/Data-) PRIVACY	39	89,0 %
(Digital-/Media-/Data-) Competence/Sovereignty/LITERACY	26	59,0 %
(Digital-/Data) ETHICS	14	32,0 %
(Data-/Information-/Decision-Making-) QUALITY	14	32,0 %
METADATA	10	23,0 %
(Knowledge-/Information-/Data-) Management/STEWARDSHIP	20	45,0 %

Source: Contribution by the authors

The first analysis of the websites using the data governance checklist showed that a large majority of the cities focus on the topics of data security (84%) and data protection (89%). This is also understandable, as this is the public sector in which regulation has a particularly strong impact (e.g. DS-GVO). Slightly more than half are aware of the importance of (digital/media/data) competence/sovereignty in the digital transformation (59%) and define measures (including training courses). In addition, the other key principles of data governance are also addressed in the areas of (digital/data) ethics, (data/information/decision-making) quality, metadata documentation and data responsibility/ownership.

Conclusions

This paper conducts an evidence-based study using an online content analysis (exploratory approach) to provide evidence on the current state of strategy initiatives in a sample of 82 German cities. This study is the first to capture strategy initiatives around smart city, digitalization and data in a sample of major German cities. It thus contributes to the understanding of the current state of strategy initiatives in this research area in German cities.

We succeeded in elaborating that the digital transformation has arrived in German (major) cities. According to the personal experience of the authors, however, strategies often exist in the heads of municipal managers and politicians, which is then also reflected in the results, because a strategy paper is publicly available in only slightly more than half of the cities studied (number = 44). Digitization of urban environments, however, concerns everyone, so its design should not be the sole preserve of responsible politicians and experts.

Furthermore, we found that the value of data is recognized, but that there is a lack of strategic approaches here as well. Only three of the 44 cities with a publicly available digitization

strategy have a data strategy, and only one has a data governance strategy. This is surprising, as there are guidelines (BBSR, 2021) and references (e.g. Amsterdam, Barcelona, Copenhagen, Eindhoven, Vienna) that German cities and municipalities can follow. This has only been recognized by Ulm, the German city with universal strategic implementation, which explicitly draws inspiration from some of these references (Ulm, 2021).

To sum it all up, the end-to-end strategic implementation of the digital transformation process, data and governance will be a crucial factor for the success of smart cities in the coming decades. And therefore, it is necessary to accompany this process from a research perspective.

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Appendix

Table A1. Sample

No.	Town	Part of Germany	Federal State	State Capital?	Major City?
[1]	Aachen	West	Northrhine-Westphalia	No	Yes
[2]	Augsburg	West	Bavaria	No	Yes
[3]	Bergisch Gladbach	West	Northrhine-Westphalia	No	Yes
[4]	Berlin	West	Berlin	Yes	Yes
[5]	Bielefeld	West	Lower Saxony	No	Yes
[6]	Bochum	West	Northrhine-Westphalia	No	Yes
[7]	Bonn	West	Northrhine-Westphalia	No	Yes
[8]	Bottrop	West	Northrhine-Westphalia	No	Yes
[9]	Braunschweig	West	Lower Saxony	No	Yes
[10]	Bremen	West	Bremen	Yes	Yes
[11]	Bremerhaven	West	Bremen	No	Yes
[12]	Chemnitz	East	Saxony	No	Yes
[13]	Darmstadt	West	Hesse	No	Yes
[14]	Dortmund	West	Northrhine-Westphalia	No	Yes
[15]	Dresden	East	Saxony	Yes	Yes
[16]	Duisburg	West	Northrhine-Westphalia	No	Yes
[17]	Düsseldorf	West	Northrhine-Westphalia	Yes	Yes
[18]	Erfurt	East	Thuringia	Yes	Yes
[19]	Erlangen	West	Bavaria	No	Yes
[20]	Essen	West	Northrhine-Westphalia	No	Yes
[21]	Frankfurt/Main	West	Hesse	No	Yes
[22]	Freiburg/Breisgau	West	Baden-Württemberg	No	Yes
[23]	Fürth	West	Bavaria	No	Yes
[24]	Gelsenkirchen	West	Northrhine-Westphalia	No	Yes
[25]	Göttingen	West	Lower Saxony	No	Yes
[26]	Gütersloh	West	Northrhine-Westphalia	No	Yes
[27]	Hagen	West	Northrhine-Westphalia	No	Yes
[28]	Halle (Saale)	East	Saxony-Anhalt	No	Yes
[29]	Hamburg	West	Hamburg	Yes	Yes
[30]	Hamm	West	Northrhine-Westphalia	No	Yes
[31]	Hanover	West	Lower Saxony	Yes	Yes
[32]	Heidelberg	West	Baden-Württemberg	No	Yes
[33]	Heilbronn	West	Baden-Württemberg	No	Yes
[34]	Herne	West	Northrhine-Westphalia	No	Yes
[35]	Hildesheim	West	Lower Saxony	No	Yes
[36]	Ingolstadt	West	Bavaria	No	Yes
[37]	Jena	East	Thuringia	No	Yes
[38]	Kaiserslautern	West	Rhineland Palatinate	No	Yes
[39]	Karlsruhe	West	Baden-Württemberg	No	Yes
[40]	Kassel	West	Hesse	No	Yes
[41]	Kiel	West	Schleswig Holstein	Yes	Yes
[42]	Koblenz	West	Rhineland Palatinate	No	Yes
[43]	Köln	West	Northrhine-Westphalia	No	Yes
[44]	Krefeld	West	Northrhine-Westphalia	No	Yes
[45]	Leipzig	East	Saxony	No	Yes

No.	Town	Part of Germany	Federal State	State Capital?	Major City?
[46]	Leverkusen	West	Northrhine-Westphalia	No	Yes
[47]	Lübeck	West	Schleswig Holstein	No	Yes
[48]	Ludwigshafen am Rhein	West	Rhineland Palatinate	No	Yes
[49]	Magdeburg	East	Saxony-Anhalt	Yes	Yes
[50]	Mainz	West	Rhineland Palatinate	Yes	Yes
[51]	Mannheim	West	Baden-Württemberg	No	Yes
[52]	Moers	West	Northrhine-Westphalia	No	Yes
[53]	Mönchengladbach	West	Northrhine-Westphalia	No	Yes
[54]	Mülheim an der Ruhr	West	Northrhine-Westphalia	No	Yes
[55]	Munich	West	Bavaria	Yes	Yes
[56]	Münster	West	Northrhine-Westphalia	No	Yes
[57]	Neuss	West	Northrhine-Westphalia	No	Yes
[58]	Nürnberg	West	Bavaria	No	Yes
[59]	Oberhausen	West	Northrhine-Westphalia	No	Yes
[60]	Offenbach/Main	West	Hesse	No	Yes
[61]	Oldenburg	West	Baden-Württemberg	No	Yes
[62]	Osnabrück	West	Lower Saxony	No	Yes
[63]	Paderborn	West	Northrhine-Westphalia	No	Yes
[64]	Pforzheim	West	Baden-Württemberg	No	Yes
[65]	Potsdam	East	Brandenburg	Yes	Yes
[66]	Recklinghausen	West	Northrhine-Westphalia	No	Yes
[67]	Regensburg	West	Bavaria	No	Yes
[68]	Remscheid	West	Northrhine-Westphalia	No	Yes
[69]	Reutlingen	West	Baden-Württemberg	No	Yes
[70]	Rostock	East	Mecklenburg Western Pomerania	No	Yes
[71]	Saarbrücken	West	Saarland	Yes	Yes
[72]	Salzgitter	West	Hesse	No	Yes
[73]	Schwerin	East	Mecklenburg Western Pomerania	Yes	No
[74]	Siegen	West	Hesse	No	Yes
[75]	Solingen	West	Northrhine-Westphalia	No	Yes
[76]	Stuttgart	West	Baden-Württemberg	Yes	Yes
[77]	Trier	West	Rhineland Palatinate	No	Yes
[78]	Ulm	West	Baden-Württemberg	No	Yes
[79]	Wiesbaden	West	Hesse	Yes	Yes
[80]	Wolfsburg	West	Lower Saxony	No	Yes
[81]	Wuppertal	West	Northrhine-Westphalia	No	Yes
[82]	Würzburg	West	Bavaria	No	Yes

Source: Contribution by the authors

THE EVOLUTION OF SMART CITIES: DRIVERS, CHALLENGES AND OPPORTUNITIES

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Abstract: Although there is no consensus on what a "smart" city is, as cities have different approaches and definitions of what it means to be a smart city, more generally, they are concerned with the integration of information and communication technologies (ICT) to increase efficiency, sustainability, and quality of life in the urban environment. Their development requires a multidisciplinary approach involving collaboration between government, the private sector, academia, and citizens. In recent years, smart cities have become increasingly popular as a solution to address the challenges of urbanization and digital transformation. Although the concept of smart cities has been around for some time, it has evolved significantly over time in response to technological advances and societal needs. Despite some initial reluctance, the usefulness of technology in improving the lives of citizens has been recognized, leading to its widespread integration in various areas. This paper aims to provide an overview of the evolution of smart cities, reviewing the relevant literature and case studies, highlighting the drivers and challenges that have led to their growth and providing a more comprehensive understanding of their evolution over time.

Keywords: smart cities; governance; evolution; ICT; challenges

JEL Classification: O21, H83

Introduction

More than half of the world's population now resides in urban regions, marking the beginning of unprecedented global urbanization. Cities have become the preferred living environment due to the opportunities they provide for both professional and personal growth as well as their advantages in terms of economy, culture, and society. As a result of this choice for urban living, an increasing number of individuals around the world have steadily migrated from rural settlements to urban centers (Mora, et al., 2019).

The infrastructure, resources, and services in cities are coming under greater pressure as urbanization has accelerated. The notion of "smart cities" has evolved as a means of transforming the idea of urban development by utilizing advancements in information and communication technology to build intelligent, interconnected, and sustainable urban ecosystems as a response to the problems encountered (Caragliu, 2009).

Urbanization, however, poses significant challenges. Rapidly growing cities all across the world are confronting issues like traffic, pollution, and urban poverty as they attempt to adjust to the pressures of industrialization and expansion. Contrary to developing areas, developed areas experience urban sprawl, which leads to an overuse of specific resources. Cities can

exacerbate global threats like resource scarcity, challenges with food and water security, and climate change while simultaneously offering a platform to address these concerns (Global Agenda Council on the Future of Cities, 2015).

Three unique scenarios are presented by Andreani et al. (2019) in terms of the characteristics of a smart city. The first scenario is technology-centric, in which technology plays a major driving and influencing role in the creation of a smart city. It entails the installation of numerous technical infrastructures, such as digital networks, mobile technologies, and virtual technologies, as well as related hardware and software. The value of people and human capital is prioritized in the second scenario, which is human-centered. It entails promoting creativity and education as crucial elements of a smart city. The third scenario is a combined strategy that takes into account both the technological infrastructure and the emphasis on people's welfare and participation in the growth of the city. A smart city must have a few essential traits to be recognized as one (Anthopolous, 2017). A smart agenda, open data, smart services or apps, and smart infrastructure are some of these necessities. There is no question regarding the city's position as a smart city because these traits are simple to verify by anyone, even from a remote place or while physically present in the city.

COVID-19 has been one of the cities' main challenges in recent years. As a result, more than two-thirds of cities will reconsider everything from urban design to how they use space, and 54% will rethink mobility, irreversibly altering how people live, socialize, and work, according to the ESI ThoughtLab study.

Throughout this paper, we have aimed to provide an overview of the evolution of smart cities by reviewing the literature and some relevant examples of smart city projects. We will highlight the drivers and challenges that have led to their growth and through these, provide a more comprehensive understanding of their evolution.

1. Literature review

There is no universally accepted definition in the literature as to what the concept of a smart city encompasses. The term 'smart city' was originally used in 1992 to illustrate the evolution of urban development towards technology, innovation, and globalization (Gibson, et al., 1992; Albino, et al., 2015). As a rule, the most common association of a smart city is with ICT, which is considered essential for the existence of the concept itself (Šiurytė and Davidavičienė, 2016). As the definitions in terms of the concept itself are not unified, in the following, we will present several definitions illustrating several facets of this concept.

According to Giffinger et al. (2007) a smart city is a city that excels in six key aspects: smart economy, smart people, smart government, smart mobility, smart environment, and smart living, by harnessing a smart combination of resources and actions of proactive, autonomous, and well-informed citizens.

The importance of ICT in the development of smart cities is also illustrated by Washburn et. al. (2010) in whose view smart computing technologies is used to enhance the intelligence, connectivity and efficiency of vital city components and services. These include various aspects such as city administration, education, healthcare, public safety, real estate, transportation, and utilities. In the OECD (2020) understanding, smart cities are defined as initiatives or strategies that effectively use digitization to enhance the well-being of citizens while providing more efficient, sustainable, and inclusive urban services and environments. These efforts are achieved through a collaborative, multi-stakeholder process. In the definition provided by the OECD, we can see that the focus is on using ICT as efficiently as possible, without neglecting the human resource and governance components.

In addition to the crucial role of technology in the development of smart cities, researchers attribute an equally important role to citizens. Schaffers et al. (2011) suggest that a city can be called „smart" when it strategically invests in human and social capital, alongside traditional and modern communication infrastructure, to promote sustainable economic growth and improve overall quality of life. This is achieved through the efficient management of natural resources and the implementation of participatory governance. Caragliu et al. (2009) define a smart city as one in which investments in human and social capital, as well as in traditional (transport) and modern (ICT) communication infrastructure, serve as catalysts for sustainable economic growth and improved quality of life. In addition, the city demonstrates wise management of natural resources and adopts participatory governance. Harrison et al. (2010) propose that a city can achieve smart city status by effectively combining its physical, social, IT and business infrastructure to harness the collective intelligence of its population.

2. Brief evolutions of Smart Cities

When the European Commission funded the construction of smart city projects in 2010, the notion of smart cities began to garner more interest from scholars. According to the literature, there weren't many studies on smart cities up until 2010. A boom of academic papers and publications on the subject was only noted with the introduction of smart city projects funded by the European Commission (Jucevičius, et al., 2014). Germany (2010) was the first nation to address this issue; the Netherlands, France, and Spain followed in 2011; Bulgaria and Luxembourg presented results in 2017; and Slovakia, Latvia, Hungary, Cyprus, and Croatia in 2016 (Correia, et al., 2022).

The idea of a smart city has now gone through four decades of development. The first generation of smart cities, known as Smart City 1.0, is thought to be mostly a technological notion (Cohen, 2015). The economy, people, governance, mobility, environment, and liveability were initially recognized as the six main pillars that made up the core criteria for this idea (Albino, et al., 2015).

Smart City 2.0 was led by city authorities and decision-makers as opposed to the technology corporations that spearheaded the first-generation smart city movement intending to sell their goods to cities (Cohen, 2015). Smart City 2.0 aimed to address social issues, enhance citizen well-being and public services, and concentrate on significant issues and requirements of citizens that go beyond technological fixes (Trencher, 2019).

The third generation, known as Smart City 3.0, placed a significant focus on the responsibility of citizens to handle their own problems and aid city administrators in locating trustworthy and workable solutions to social, environmental, and governmental issues in cities (Cohen, 2015). The smart city concept has a wider potential for tackling urban difficulties in this iteration, which also acknowledges that smart solutions are not only focused on technology-driven concepts (Pira, 2021). In addition to the elements present in the previous generation, the scope of Smart Cities 3.0 has expanded in comparison to the other two versions to cover social, equity, educational, or environmental challenges (Makieła, et al., 2022).

In terms of Smart Cities 4.0, they maintain hyper connectivity, all data-related components, and citizen engagement; in other words, they retain all the features of previous iterations but use them to further the objectives of sustainable development (Makieła et al. 2022). This suggests that a smart city must be both smart and sustainable. The development of how cities respond to new difficulties has been influenced by the technological or social developments brought about by the Covid-19 Pandemic. Given this environment, it follows that firms are preparing for a fourth industrial revolution and that public expectations are rising. The most successful cities in the current setting will be those that have made more progress in implementing the SDGs; these cities are known as Generation 4.0 cities (ESI ThoughtLab).

Different perspectives on the smart city have emerged as a result of the diversity of sectors requiring technological and social solutions. Depending on the significance of information technology in the sector, the literature classifies them into two major categories, namely „hard" and „soft" domains. The „hard" domains are metropolitan settings, where the 'city that can feel and respond' finds its greatest practical application through the employment of sensors, wireless technology, and software solutions to manage massive amounts of data. (Neirotti, et al., 2014; Manyika et. al., 2011). Office and residential structures, energy grids, natural resources, energy and water management, waste management, the environment, transportation, mobility, and logistics are all included in this area (Neirotti et. al., 2014).

The „soft" areas, which include a wide range of activities in education, culture, policies to foster entrepreneurship, innovation, and social inclusion, as well as communication between local governments and citizens through e-government projects, are in addition to the „hard" sectors. Information technologies, in contrast, play a far more significant role in the „hard" domains, although this is much more limited in the „soft" domains. The emphasis is not on the adoption of new technologies in situations like innovation and social inclusion policies, but rather on government interventions to create favorable social and institutional conditions, like the provision of incentives or the establishment of specialized organizational bodies. The 'hard' and 'soft' domains overlap in terms of public health and safety. The deployment of sensors and wireless technology, such as the use of such technologies for remote patient care, maybe a part of smart city interventions in these settings (Neirotti et. al., 2014).

As we've seen above, the idea of a „smart city" is not new, but it has started to take shape significantly in recent years, largely in response to the problems brought on by the challenges of urbanization's continued growth, the digitalization of society's demands for more effective and sustainable services, and, as a result of the foregoing, higher living standards. Urban planning, city infrastructure, sustainability, mobility, public safety, health, and public policies are among the seven variables that Guedes and his colleagues found to be most important in fostering the growth of smart cities. They claim that the aforementioned elements are somewhat related to governance, demonstrating the significance of public administration in the growth of smart cities (Guedes, 2018). According to Camboim et al. (2018), the process of converting a conventional city into a smart city is driven by the governance dimension, which is consistent with what we previously said. According to Fernandez-Anez (2017), initiatives about governance are at the forefront of the development of other aspects of smart cities and are viewed as practically necessary for their success (see, for example, Albino, et al., 2015; Nam & Pardo, 2011).

Anthopolous (2017) argues that people should reevaluate their expectations of a smart city and realize that it aims to improve local life in the face of challenges (climate change, economic growth, etc.) and improve urban planning, and is not strictly limited to the concept of a city that is easily controllable by citizens. This is in response to a review of 10 representative smart city paradigms from the literature, covering different classes of cities, sizes, and continents. So, according to Paulin (2016), a much larger emphasis on the needs of the citizens must be included in the planning of smart city projects.

Uncertainty, diversity, and complexity are the main characteristics of modern cities, per a study by Fernández-Güell et al. (2016). The many operational processes that take place in cities, which have a non-linear dynamic and can adjust to changes, are what give cities their complexity. Contrarily, diversity is produced by the diversity of regional participants in the socioeconomic activities of the city. The third quality, uncertainty, results from all the changes that take place in a city.

According to a report by the Global Future Council on Cities and Urbanization (2020), several issues that are common to many of the world's cities, such as congestion, poverty, population

growth, a lack of infrastructure, vulnerability to climate change, and natural and man-made disasters, can be encountered during the implementation of smart city applications. The number of smart city apps has also grown over the years as cities have developed. In 2012, according to the graph below (see Figure 1), where the data shows the number of projects in progress or implemented and classified by region, in North America there were 35 projects, South America had 11 projects, Europe had only 47 projects, Asia had 40 projects, and the Middle East and Africa had only 10 projects (Lee and Hancock, 2012).

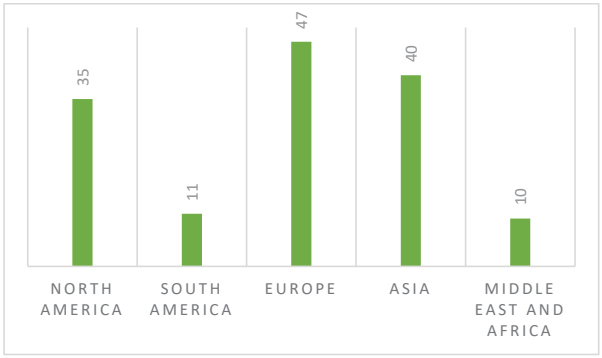

Figure 1: Number of projects being implemented or implemented globally

Source: own computation from Lee and Hancock, 2012

According to Guidehouse Insight (see Figure 2), a total of 250 smart city projects were identified in 178 cities in 2017. Gradually, the number of projects has increased, reaching a total of 619 projects in 2021 within 353 urban areas (OSINT, 2021).

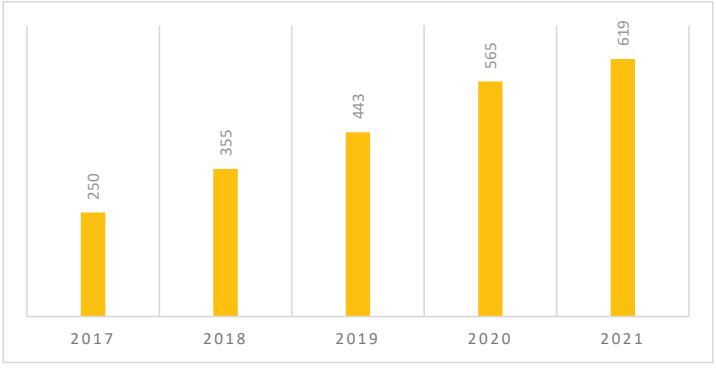

Figure 2: Evolution of the number of smart cities projects between 2017-2021

Source: own computation from Guidehouse Insights, 2021

Correira et al. (2022) used content analysis to evaluate the contribution and geographic distribution of each paper in their study, which attempted to gather data from already-existing smart city programs inside the European Union. They did this to count and categorize the initiatives in each nation. The study's findings show that different European nations have developed smart cities at different rates.

It's interesting to note that despite their membership in the European Union, differences persist not only between cities and regions within the same country but also between various nations. Although every member of the European Union is represented in the study by the literature

findings, there is still a sizable gap between the member states. While the various starting years of the literature results can be somewhat blamed for this disparity, it does not offer a comprehensive explanation. For instance, the first literature results were released in Slovenia, the Czech Republic, Italy, and Ireland in 2013, although the overall results varied greatly among them. These differences can be attributed to local governments' differing levels of involvement and investment prioritization in smart city efforts. The study highlights the fact that, despite the European Union's efforts to progress this issue, its strategy lacks standards and enforcement.

Following, we'll give some examples of good practices in carrying out initiatives that support cities' aspirations to become smarter and more effective.

The Municipality of Berlin and Hush City Mobile Lab worked together to create Hush City Mobile Lab. They have created a free smartphone app that directs users to peaceful neighborhoods. (Global Future Council on Cities and Urbanization, 2020) The Hush City app uses crowdsourcing to identify quiet areas and rates them based on their noise levels, descriptions, visual appeal, and accessibility.

The initiative addresses a crucial issue in European policy that has ramifications for research, policy planning, public health, the economy, the environment, and society as a whole, according to the Global Future Council on Cities and Urbanization. Traffic noise is the second-worst environmental issue in Europe, although it has received little attention in the public health agenda. Significant health concerns from excessive noise exposure result in high expenditures to society.

Fukuoka City's location limits its access to water, and the only rivers in and surrounding the city are rather small. Water restrictions were implemented during a severe drought in 1978 and a protracted spell without rain, which ultimately lasted 287 days (Fukuoka Now, 2014). As a result, the city has created a system that uses specialized sensors to concurrently monitor and control water flow and pressure in each region of the city. Additionally, the city can forecast the water requirements for each location by employing prediction models based on analytical information from the sensor data, enabling an effective water distribution network throughout the city. 90% of city residents are therefore committed to conserving water. (Global Future Council on Cities and Urbanization, 2020).

With more than 450 kilometers of bike lanes, Copenhagen is at the forefront of cycling infrastructure. Each day, 36,000 bikers use these lanes. These were the outcome of a 2007 initiative that comprised a well-connected network of 2.2-meter-wide cycle lanes on both sides of city streets, situated between pavement and cars. Footrests at traffic lights and other new features like synchronized traffic signals („green wave") have also been included. Additionally, Copenhagen is now known for its famous bicycle-friendly features like the Cykelslangen, which rises above the ground. People of all ages and social classes have undergone a noticeable cultural shift toward embracing cycling, which has been aided in part by projects like Copenhagen's Cycle Chic blog (Global Future Council on Cities and Urbanization, 2020). The average daily cycling distance for Copenhagen residents is 1.44 million kilometers. Bicycle travel now accounts for 49% of all commutes to work or school, up from 35% just ten years ago. The upshot of such municipal funding is the rapid rise in cycling over the past ten years. The municipality has committed to spending more than €40 per person on bicycle infrastructure (Thoem, 2023).

Buenos Aires, with a population of over 3 million people scattered over an area of 78 square miles, contains about one million public infrastructure elements. For many years, the city has provided a call center where individuals can submit complaints or requests for services ranging from pothole repair to graffiti removal. Unfortunately, this feedback method has been exceedingly unsuccessful, with the city resolving complaints in an average of 600 days (almost

two years) since 2011. The city launched a smartphone app that allows individuals to lodge grievances in order to improve the overall procedure. The software makes use of integrated geographic information system (GIS) technology, which immediately sends the complaint's location to the relevant ministry, allowing it to assign the assignment to the closest supplier for speedy resolution. To close the feedback loop, a city street inspector with a mobile device checks the vendor's work and uploads a photo via the app to show that the issue has been repaired properly. This responsive approach has had a significant influence on the city's quality of life, as the average time to resolve a complaint has lowered by an incredible 93%, all while requiring no new budget allocations. As a result, the city can now resolve more concerns in substantially less time (Deloitte, n.d.)

Significant advancements in several areas throughout recent years have sparked considerable interest in the development of smart cities. This has brought to light the many benefits of intelligent solutions in activities like recognizing sick people, forecasting the dynamics of the spread, minimizing human-to-human contact, and imposing social distance and quarantine rules. The development of efficient response and recovery techniques has been greatly aided by these technical breakthroughs.

Although technology-driven initiatives have shown to be more successful, there are valid concerns about how they might affect power relations and privacy. A balanced strategy that incorporates technical solutions and human interaction is necessary to address these concerns and improve preparedness for future catastrophes. This mixture not only aids in reducing the problems that have been recognized but also encourages increased awareness and adaptation for the future (Sharifi and Khavarian-Garmsir, 2020).

Conclusions

While in the early 1990s, the concept of „smart city" revolved mainly around ICT issues, its scope has expanded considerably in recent decades, indicating the evolution of the concept itself as cities increasingly strive to become smart cities.

The COVID-19 pandemic has forced us to rethink our future, and therefore the future of the cities we live in. There has been a significant increase in the number of remote jobs, the effects of which will spill over into transport or consumer habits, with the workforce having to reshape itself as we move towards increased automation. The emergence of the COVID-19 pandemic has necessitated the deployment of technology-driven activities, leading to an acceleration of digitization. As a result, many of the measures adopted at that time are still in place today. It is important to note that the pandemic also contributed in some ways to the development of cities, propelling them further towards the goal of becoming smart cities. On the other side of the coin, the pandemic has also had negative effects on cities. Due to the overstretched healthcare system and the allocation of more money to actions to stop the spread of the virus, governments have had to redistribute funds or even reduce budget revenues, leading to a decrease in the number of smart city projects.

Acknowledgements: This work was supported by Jean Monnet Module "European Smart Cities for Sustainable Development"-SmartEU, co-funded by the European Union (620415-EPP-1-2020-1-RO-EPPJMO-MODULE) and the Faculty of Economics and Business Administration, Alexandru Ioan Cuza University of Iași, Romania.

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DIGITAL SKILLS OF PRIMARY SCHOOL PUPILS FROM ROMANIA

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Abstract: The Covid-19 pandemic has shown the facts that education and training based on digital skills are essential for the digital age we are in. Perhaps this pandemic would not have been necessary, but the medical situation imposed by the Covid-19 pandemic has shown that it is necessary that the digitization of the educational process starts at the primary school level and not at the secondary school level, because it is at this level that digital education and training tools are used. So far, few schools in Romania have introduced Informatics and ICT as optional subjects at the primary school level, although pupils have native digital skills that should be further developed and improved. Starting from these premises, the aim of this paper is to find answers to the following questions: What is the level of digital competence of primary school pupils? Which digital competencies need to be developed from primary school onwards? What digital skills should pupils have at the end of primary school? The methodology used to obtain answers to these questions is based on literature, official documents published by European Commission offices and statistics issued by specialized bodies. The conclusion that emerges is that a pupil at the end of primary school should have at least basic digital skills.

Keywords: digitization; education; digital skills

JEL classification: H520, I210, I250

Introduction

As a teacher in a school in the metropolitan area of Iasi, I was able to see first-hand the contribution of IT during the Covid-19 pandemic to the educational process. For the school where I taught, the pandemic was not the starting point of digitization, but only a stage in this broad process. Basically, long before the onset of the Covid-19 pandemic, the school had a high-speed internet connection, a computer lab and equipment to conduct classes in an information-friendly format. There was also a digital whiteboard, obtained through a grant in 2010, and used in the preparatory class. Although teachers used mainly traditional teaching and listening methods, they also used technology in some lessons, albeit at a low level, depending on each teacher's lesson plan. The year 2020 was a decisive step in the digitization of schools: every pupil in the school receives a tablet connected to the internet on which the necessary apps for online schooling are installed. In addition, 2 video cameras are installed in each classroom to which pupils who could not come to school can connect, and the teachers in charge receive a laptop and a tablet. The year 2021 starts with an educational investment that consists of installing a digital board in each classroom. This is a happy case, but there are many schools in Romania that have no internet connection, no computer lab and no teachers with minimal digital skills. Another unseen part of the Covid-19 pandemic concerns the digital skills students need to have to access online courses. While secondary school students have basic digital skills, primary school students, while having native digital skills, need the help of another person with

basic digital skills to access the online environment. Therefore, in this paper, we will analyze, with the help of a literature review, official documents published by European Commission offices and statistics issued by specialized bodies, the level of digital competencies among primary school pupils. As a result, we will get answers about the level of digital competencies of primary school pupils, identifying which digital competencies should be developed already in primary school and which digital competencies pupils should have at the end of primary school.

1. Education and digitalization

Kant (2002) said that man can become man only through education and that he is nothing but what education makes him. Indeed, a man without education is a caveman, an individual incapable of self-improvement and adaptation to the new. Education involves not only the process of "feeding" an individual with "ideas" in order to bring him out of an "inferior-natural" state and raise him to a "superior-cultural" state, but education also means the development of the intelligence, affectivity and will of either a child, youth or adult (Marin, 1996). Education is therefore a complex process of conscious influence, by appropriate means, undertaken by a person or group of people on other people with the intention of developing an ideal in them. Of course, this ideal may differ from era to era, but it remains broadly the same: an educated human being, capable of evolution and accepting the new. With this in mind, education or the educational process must make use of new information technologies to achieve its goal. Otherwise, it runs the risk of remaining out of date as we saw during the pandemic of Covid-19 (Ministerul Educației și Cercetării, 2020a) when the education system was seen to:

- lacks predictability.
- does not have a heterogeneous school network and there is a strong digital divide between educational establishments.
- is insufficiently developed for the efficient organization of the teaching process in the online environment.
- is limited in terms of access to technology and internet connectivity.
- is unable to offer poor families the possibility to benefit from online education when they lack the financial resources to purchase IT equipment and an internet subscription.

After the experience of pandemic Covid-19, we can conclude that digital technology needs to be integrated into the lives of individuals from an early age, even at the primary level, not as a fad but as a necessity. In fact, a series of statistics carried out by the Romanian Institute for Evaluation and Strategy within the *EU Kids Online 2018*[1] project, long before the Covid-19 pandemic, based on a sample of 935 boys and girls aged 9–17 between March and April 2018, gives us good news regarding the digital skills of Romanian students. We will detail these in another section.

However, the Romanian education system needs to adopt digitalization as an integral part of the education and training process from primary school onward. However, adapting the education and training system to the technological evolution is a complex process, as foreseen in *The Strategic Initiative for Digitization of Education in Romania SMART-Edu 2021-2027*. And this adaptation needs resources, especially financial resources, and not only human resources because the digitization of education requires large expenses but also because education is an essential element of the development, modernization, and innovation of society.

[1] EU Kids Online is an internationally recognized project as a competent source of robust comparative data on children's internet use in Europe. The network of researchers currently includes members from 33 countries bringing together multi-methodological approaches to children's internet safety.

What needs to be understood is that through the digitization of education, teachers and pupils can access an increasing number of technologies and resources, use collaborative platforms, and all of this to improve their teaching and learning practices. The digitization of education must start by translating text, images, video, and audio into a digital format that can be played back by devices (Bejinaru, 2019). And it must continue by storing them in the cloud. From the cloud, they can be used anytime, anywhere.

Time is passing, and digitization has already begun to transform many aspects of work and everyday life. Basically, digitization is reshaping society and the labor market for a digital future. It is already being seen in the workplace that the lack of digital skills of future employees is making it difficult for employers, especially in IT, to recruit highly skilled employees in many sectors of the economy because too few adults take the time to upgrade their digital skills after finishing school (European Commission, 2020).

2. Primary school in Romania

Between the ages of 6 and 10, children in Romania attend primary school, starting with the preparatory class and ending with the fourth grade. This period is one of "child maturation", characterized by the development of the inner dimension, a beginning of autonomy and self-determination (Osterrieth, 1976).

According to the Romanian Ministry of Education and Research, the primary cycle is the first stage of compulsory education and aims to create equal opportunities for all children to achieve a balanced cognitive, emotional and psychomotor development adapted to individual needs (Ministerul Educației și Cercetării, 2023a).

A very important role in the life of the primary school child is played by the teacher, who must create a suitable environment for his/her pupils, using traditional teaching and learning methods and new methods linked to new information technologies. This is because today's pupils already have a range of digital skills and abilities that sometimes exceed those of the teacher. It is therefore the responsibility of the primary school teacher to support the pupil in acquiring digital skills, if he or she does not already have them, or to improve them through methods and channels accessible to the level of knowledge of the young pupil.

During the 5 years of study, the primary school pupil, based on the subjects studied in class, learns to read and write, to do simple and more complex mathematical calculations, to know nature and the environment, to know the history of the country and much more. Communication in Romanian, modern language, mathematics and environmental exploration, visual arts and practical skills, music and movement are some of the subjects studied by primary school pupils. But all these disciplines can be improved through digitization. For teachers, the digitization of the educational process is a process with beneficial effects on pupils' education. In an interview at an urban secondary school in Iasi, all teachers stressed that digitization made lessons more attractive, and pupils were more active in class. For these teachers, digitization means using technology to combine traditional and modern teaching and learning methods.

3. Digital competences

According to UNESCO digital competencies are a set of skills for using digital devices, communication applications and networks to access and manage information. These skills include creating and sharing digital content, communicating, collaborating, and solving problems effectively and creatively (UNESCO, 2023). Digital skills are divided into the following categories:

1. Basic skills, and refer to:
1.1 Communicating via email.

1.2 Searching for information online.
1.3 Handling sensitive information in virtual ecosystems.
1.4 Safely using cloud-based collaboration tools such as Google Drive, Drobox and Microsoft Teams.
1.5 Creating and managing spreadsheets and documents online.
1.6 Basic device management, such as connecting to the internet or installing software updates.
1.7 Screen sharing during a video call.
1.8 Using online calendars and effectively managing your schedule (UNLV, 2022).

2. Advanced skills - enabling users to use digital technologies in database management, systems management, work process analysis, data analysis, and scheduling.

According to Eurostat (2020), in 2019, four out of five young people (80%) aged 16-24 in the European Union (EU) had basic or above basic digital skills. Croatia had the highest proportion of 16–24-year-olds with basic or above basic general digital skills (97%), followed by Estonia, Lithuania, and the Netherlands (all three 93%), and Greece (92%), while at the bottom of the ranking were Romania (56%), Bulgaria (58%), Italy (65%), Hungary (68%), Latvia and Luxembourg (both 75%).

4. Digital skills of Romanian pupils

According to the methodology developed by the Romanian Ministry of Education and Research, only at the end of high school does a test of digital skills take place as an integral part of the baccalaureate exam, as test D: digital skills assessment test (Ministerul Educației și Cercetării, 2020b). Since 2011, all those registered for the baccalaureate examination have taken this test, in accordance with the baccalaureate syllabus, based on the curriculum of the subject "Information and Communication Technology", studied in the common core in all streams, profiles, and specializations, during the 9th and 10th grades (Ministerul Educației și Cercetării, 2011). In the last two years, the examination has been only for candidates who have not studied the subject Information and Communication Technology during high school in the 9th and 10th grades, respectively. For those who had studied this subject in the ninth and tenth grades, a score from 5 to 10 was calculated based on the arithmetical average, without rounding, of the annual averages obtained in the subject of information and communication technology in the ninth and tenth grades, respectively, according to the following scale:

- Beginner user: for averages between 5 and 5.99.
- Intermediate user: for an average between 6 and 6.99.
- Advanced user: for an average between 7 and 8.49.
- Experienced user: for an average between 8.50 and 10.

Candidates who have not studied Information and Communication Technology or equivalent subjects take the Digital Skills Assessment Test (Test D) according to the *National Examination and Assessment Centre Procedure No 177/2019 of the Romanian Ministry of Education and Research*, for the organization and conduct of the Digital Skills Assessment Test (Test D) (Ministerul Educației și Cercetării, 2019).

For the year 2023, test D has been reintroduced for all candidates (Lefter, 2022). In it, candidates will have to solve 2 worksheets in 90 minutes:

- For sheet A, students have 15 minutes with access to the Internet to solve some topics, which consist of searching on the Internet for information, saving the web page in the working folder and copying a paragraph, an image, links, etc. to a document in the working folder,

- For worksheet B, students have 75 minutes, without an internet connection, to solve some theoretical and practical questions. The answers to the theoretical questions may cover information on computer systems, computer architecture, operating systems, processors, types of memory, peripheral devices (keyboard, mouse, printer, etc.), computer networks, the Internet, etc., while the practical requirements concern the processing of files in the workbook. In this folder, pupils will find a Word, Excel, PowerPoint, Access, HTML, Notepad file/document, an image, and an archive.

As a result of the teachers' strike at the end of the 2022-2023 school year, the D test was again eliminated from the Baccalaureate exam, according to the Draft Emergency Ordinance for the establishment of measures for the proper functioning of the education system, no. 35/2023 (Edupedu, 2023). According to the methodology or the equivalence/recognition of competence levels in the language and digital competence assessment tests - national baccalaureate exam 2023, article 6, paragraph 1: The level of digital competence in test D in the national baccalaureate exam 2023 is established by calculating a score from 5 to 10 based on the arithmetic average, without rounding, of the annual averages obtained in the subject of Information and Communication Technology in classes IX and X respectively. The same grid of digital competence levels is maintained: - 'beginner user' for an average between 5 and 5.99; - 'intermediate user' for an average between 6 and 6.99; - 'advanced user' for an average between 7 and 8.49; - 'experienced user' for an average between 8.50 and 10. Paragraph 7 specifies that in the case of candidates for the 2023 national baccalaureate examination who have not studied Information and Communication Technology or its equivalent in secondary or vocational education, but who have taken an examination/exam of equivalence of studies in Information and Communication Technology or its equivalent, the level of digital competence is determined solely on the basis of the mark obtained by the candidate in the examination/exam of equivalence (Ministerul Educației și Cercetării, 2023b).

And yet, according to Eurostat (2021), in Romania, in 2021, among the population aged 16-19 years:

- 50.13% are people with basic or above basic general digital skills,
- 14.69% are people with general digital skills above the basic level,
- 35.44% are people with basic general digital skills,
- 21.91% are people with low general digital skills,
- 13.13% are people with low general digital skills,
- 6.99 are people with limited general digital skills,
- 5.05% are people with no general digital skills.

5. Basic digital skills for primary pupils

It seems that *The Strategic Initiative for Digitization of Education in Romania SMART-Edu 2021-2027* seems to be a failure, because even in the school year 2022-2023, compulsory elements of digital skills, promised for the school year 2021-2022, have not been introduced in primary school, with the idea that in 2027 90% of the Romanian population will have basic digital skills (Krasavina, 2021).

However, if computer science and ICT elements were to be introduced into the primary school curriculum, they should aim for pupils to have the following digital skills by the end of primary school:

- Effective and safe use of hardware components.
- Effective use of software components.
- Effective and safe use of the Internet as a source of documentation.

- Develop graphical animations and 3D models using specific operations to dynamically illustrate various themes.
- Develop presentations using specific operations to illustrate various themes.
- Using specialized tools to produce digital material.

In this respect, the primary school curriculum should include lessons about:

- **Computing systems**: General structure of a computer system, The role of hardware components of a computer system, Input, output, input-output devices: examples, role, use, Data storage devices: examples, units of measurement for storage capacity, Description of the software component, Interface elements of an operating system, Organization of data on external media and File and directory operations.
- **Internet**: What is the Internet? Structure, Services; World Wide Web service: surfing the Internet, searching for information on the Internet using search engines, saving information from the Internet; Copyright; Internet security; Surfing the Internet; Searching for information, saving information.
- **Graphic editors**: The role of a graphic editor; Specific interface elements; Creating, opening and saving graphic files; Commands for selecting, copying, moving, deleting; Resizing, truncating, and rotating an image; Image panning; Drawing tools; Using colors in image processing; creating custom colors.
- **Presentations**: Basic rules for giving a presentation. Basic rules of aesthetics and ergonomics are used in making a presentation. Interface elements of presentation applications. Presentation management operations. Operations for editing a presentation. Structure of a presentation: slides, objects used in presentations. Formatting them. Animations and transition effects.

This **curriculum** would help primary school children to have basic digital skills by the end of grade 4.

In fact, data confirms that the 9–17-year-old generation in Romania has above basic digital skills. In this regard, we recall the results obtained from data collected on a sample of 935 boys and girls aged 9-17, between March and April 2018 by the Romanian Institute for Evaluation and Strategy, within the EU Kids Online 2018 project, which showed the following (Velicu, Balea and Barbovschi, 2019):

- 86% know how to save a photo found online, and 75% know how to change the privacy settings of their own profile on an online social media platform).
- 71% say it is easy for them to check if the information they find online is true, with the same 71% confident in their own ability to be effective in choosing keywords for online searches.
- 84% say they know what information to share online and what not, and 90% know how to delete someone from their online contact list.
- 78% of respondents say they know how to create and post videos or music online, and just over half (55%) know how to edit or make changes to content, images, and videos created by others.
- 90% know how to install an app on their mobile or tablet, and slightly fewer (77%) know how to keep track of mobile app costs or how to buy things in a mobile app.

Conclusions

The Covid-19 pandemic was a turning point in the digitization of education in Romania. Practically from that moment on, the question has been asked what digital skills students should have in the event of a new pandemic. During the Covid-19 pandemic, it was possible to observe the reality that while those in secondary and pre-university education had basic digital skills,

those in primary education, although they had native digital skills, needed the help of another person with basic digital skills to access the online environment. Therefore, from the experience of Covid-19, we can conclude that digital technology needs to be integrated into the lives of individuals from an early age, even at the preparatory class level, not as a fad but as a necessity. To this end, elements of computer science and ICT should be introduced into the primary school curriculum, so that at the end of primary school pupils will have the following digital skills:

- Effective and safe use of hardware components.
- Effective use of software components.
- Effective and safe use of the Internet as a source of documentation.
- Develop graphical animations and 3D models using specific operations to dynamically illustrate various themes.
- Develop presentations using specific operations to illustrate various themes.
- Using specialized tools to produce digital material.

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PLAYING FAIR: ETHICAL CONSIDERATIONS IN MARKETING TOYS AND GAMES TO CHILDREN

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Abstract: Advertising and advertising content are important components of the consumer socialization process. Advertising helps children discover products available on the market and shapes their desires, attitudes, and behavior. Advertising targeted at children is subject to specific regulations. It must follow certain ethical standards that contribute to protecting the interests of the vulnerable public, children. This research is based on a literature review. It aims to achieve two objectives. The first objective is to identify the main ethical aspects related to advertising for games and toys targeted at children. The second objective of the research is to illustrate the main regulations in the field of marketing for children's games and toys in Romania. We illustrate these aspects by comparing the regulations in the European Union. Some countries have made significant changes, which we present to compare the regulations in Romania with those in other EU states. We aim to identify whether there are aspects in Romania that have been regulated in the European Union but have not yet been regulated in Romania, which could improve the ethics of marketing products aimed at children. The research proposes new regulations and standards based on the literature reviewed.

Keywords: ethics, marketing, advertising, toys and games, consumer socialization, European Union

JEL classification: I3

Introduction

Educating children involves various activities aimed at helping them develop and prepare for adulthood. One aspect of this education prepares children to become consumers, which involves steps in the consumer socialization process, including exposure to marketing and advertising messages. Advertising expose children to the products on the market and influence their desires and behavior. Research on marketing children's products examines various aspects, such as the socialization of children as consumers (John, 1999), the kids' market (McNeal, 1999), the need for advertising education (Buckingham, 1993), and ethical marketing (Murphy, et al., 2016). Among all the products aimed at children, the marketing of games and toys is particularly relevant due to its potential impact on children's well-being and harmonious development (Calvert and Wilson, 2008, pp.22-23; Valkenburg and Piotrowski, 2017, pp.63-77). In this context, discussions often revolve around the ethical issues associated with marketing children's products, especially toys and games.

We can discuss two perspectives on this issue. On the one hand, we have the perspective of advertising practitioners who face challenges in balancing ethical considerations with business objectives and customer requirements (Richardson-Greenfield and La Ferle, 2021; Drumwright

and Murphy, 2009). In a market where the number of products and sales requirements is increasing, practitioners have to balance business objectives with ethical principles.

On the other hand, we have the interests of children, a vulnerable group for whom understanding advertising messages is difficult (Calvert and Wilson, 2008), as well as the interests of parents who are burdened by sales proposals (John, 1999; Carlson and Grossbart, 1988). While advertising can help shape children's demands and actions, there are concerns about their protection and the need to provide them with appropriate and safe information.

Additionally, parents face an increasing burden in the face of constant sales proposals, having the responsibility to protect and guide their children in the consumption process (Sidebotham, 2001; Brusdal, 2007). They must navigate through numerous advertising messages and make informed decisions to ensure the well-being of their children.

This situation highlights the importance of finding a balance between the commercial interests of advertising practitioners and the needs and rights of children and parents. An ethical and responsible approach is necessary for advertising targeted at children, promoting a clear understanding of messages, avoiding manipulation, and protecting the interests and well-being of children.

This research is grounded in a literature review with the aim of achieving two objectives. Firstly, we aim to identify and discuss the ethical issues presented in the literature regarding the marketing of games and toys to children. Secondly, we seek to present the main regulations in this field in Romania and compare them with the regulations in the European Union. We will illustrate these aspects by examining the changes made in some EU countries and comparing them with the regulations in Romania. The goal is to identify any aspects that have been regulated in the European Union but not yet in Romania, which could potentially improve the ethics of marketing products aimed at children.

1. Ethical consideration in marketing toys and games to children

Numerous articles extensively address the ethical considerations surrounding the marketing of games and toys to children. These articles explore different facets of the ethical implications in this area, covering various areas ranging from the impact on children's harmonious emotional and cognitive growth to examining cultural issues and stereotypes. In the following paragraphs, we will outline the key issues explored in the existing literature.

Impact on Child Development - Several studies and publications collectively emphasize the profound impact of advertising on child development, including desires, attitudes, and behavior, as well as cognitive, emotional, and social development (Opree, et al., 2016; Lwin, et al., 2008; Valkenburg and Buijzen, 2005; Chan and McNeal, 2003; Goldberg, et al., 2003). They provide insights into the influence of violent video games (Calvert, et al., 2017; Ferguson, 2015), food advertising (Hudders, et al., 2016; Livingstone and Helsper, 2006), television mediation (Valkenburg, et al., 1999), consumer culture (Dittmar, 2007; Armstrong and Kotler, 2011, pp.86-87; Buckingham, 2007), and the relationship between advertising and product experiences in children (Moore and Lutz, 2000). By understanding these influences, ethical considerations can be implemented to promote healthier development and well-being among children in the context of marketing and advertising.

Calvert, et. al. (2017) examines the influence of violent video games on child development. The study highlighted how exposure to violent video game advertisements can shape children's desires for aggressive play, attitudes towards violence, and subsequent aggressive behavior. The research emphasizes the importance of considering the potential negative impact of such advertising content on children's cognitive and emotional development. In another study, Armstrong and Kotler (2011, pp.206- 207) discussed consumer culture and its impact on child

development. They highlighted how advertising campaigns for children's products contribute to children's identity and well-being. In one article, Dittmar (2007) explored the potential influence of consumer culture on children's desires, materialistic attitudes, and the pursuit of an idealized "body perfect", leading to potential negative consequences for their psychological and social development. The study explores the relationship between consumer culture, identity, and well-being in children. The study delved into how advertising and the promotion of materialistic values can shape children's desires, self-perception, and overall happiness. It highlighted the need for ethical considerations in advertising practices to foster a healthier and more sustainable approach to consumption among children.

Research in the field frequently discusses the lack of defense of children as young as 6-8 years of age to advertisements. At this age, children do not have a well-developed rational cognitive area or the ability to delay rewards, so they have difficulty understanding the intentions behind advertisements and tend to believe all the claims made in them. Pre-adolescents, aged 8 to 10, possess the cognitive capacity to process advertisements but may not necessarily do so unless prompted. Unfortunately, most research on youth consumer behavior has been conducted by marketing researchers and remains unavailable to the academic community or the public. Secondly, what children see can harm them in various ways. In the case of toys, advertising inflates their value and can encourage materialism in children. In a 1999 survey of a sample of 400 parents, the non-profit Centre for a New American Dream found that 87% of respondents believed that advertisements increase materialism and cause their children to want more things, and 63% said their children use the number of possessions they have to describe their confidence and self-esteem. Nearly one-third of parents reported working longer hours to afford such toys (Strasburger, 2001). Previous research on TV commercials has shown a link between exposure to advertising and materialism (Loose, et al., 2022).

Ethics in this sphere, given that we are talking about a vulnerable target audience, involves more than that. To change the understanding of the role of marketing for products aimed at children, especially the values frequently conveyed such as materialism and the association of happiness with the possession of a good, following Calvert and Wilson (2008), three strategies should be applied: regulating and restricting children's access to advertising, educating children about marketing techniques, especially those related to persuasion, but also illustrating other forms that bring happiness in life, such as love, friendship, and play.

Honesty and Truthfulness: Avoiding misleading or deceptive advertising practices – articles highlight the negative consequences of misleading or deceptive tactics on consumer trust (Hackley and Hackley, 2015), decision-making (Ukaegbu, 2020), and the effectiveness of advertising campaigns (De Pelsmacker, et al., 2002). By adhering to ethical standards and maintaining transparent communication with consumers, advertisers can foster trust, credibility, and long-term relationships with their target audience.

In one study, De Pelsmacker, et. al. (2002) explore the influence of context on advertising effectiveness. It emphasizes the importance of honesty and truthfulness in advertisements to maintain consumer trust and prevent negative reactions. Misleading or deceptive practices can lead to skepticism and reduced effectiveness of advertising messages.

The 2004 report titled "Report of the APA Task Force on Advertising and Children" (Wilcox, et al., 2004), published by the American Psychological Association (APA), provides a detailed overview of the effects of advertising on children. The report reviews the existing research literature on advertising and children and highlights the psychological, developmental, and societal impacts of advertising on young audiences. It addresses various aspects of advertising, including the marketing of toys and games, and offers recommendations for policymakers, industry stakeholders, and parents to promote responsible advertising practices and protect children from potentially harmful influences. The report is a valuable resource for

understanding the connection between advertising and the harmonious development of children and provides guidance for addressing ethical considerations related to advertising to children.

Exploitation and Manipulation: Protecting children from coercion and harmful behaviors – this section addresses issues such as the impact of media models (Dittmar and Howard, 2004), materialistic parenting practices (Richins and Chaplin, 2015), and the potential for coercive behavior and harmful consumption patterns (McNeal, 1999; Calder, et al., 1981).

One such issue is the impact of media models on children. The study by Dittmar and Howard (2004) explores how exposure to idealized media models can influence children's self-perceptions, body image, and materialistic values. It highlights the potential for exploitation and manipulation by presenting unrealistic standards and promoting materialistic desires.

Another aspect is the role of materialistic parenting practices. Richins and Chaplin (2015) examine the effects of materialistic values transmitted by parents on children's well-being and consumer behavior. Their research suggests that materialistic parenting practices can contribute to negative outcomes, such as increased materialism and decreased psychological well-being in children. Another longitudinal study investigates the relationship between materialism and consumer socialization, with a focus on the influence of marketing messages and toy consumption (Nelson, 2014). It examines how exposure to materialistic values through advertising and marketing practices can shape children's attitudes and behaviors towards material possessions. Goldberg, et. al. (2003) examine how materialistic values are shaped by exposure to consumer culture and the role of toys and games in fostering materialistic tendencies.

While not specifically focused on toys and games, Buijzen and Valkenburg (2003) in this review article examines the unintended effects of advertising on children, including the promotion of materialistic values. It discusses the influence of advertising in shaping children's desires and the potential consequences of excessive materialism. Richins and Dawson (1992) in a seminal study develop a scale to measure materialism and explore the underlying consumer values associated with materialistic tendencies. It identifies which aspects increase materialism among children and adolescents, including the impact of marketing messages related to toys and games.

Additionally, McNeal (1999) discusses the potential for coercive behavior and harmful consumption patterns in the children's market. The study emphasizes the importance of understanding children's vulnerability to marketing tactics and the need for responsible advertising practices that prioritize children's well-being over profit.

By promoting ethical marketing practices and safeguarding children's well-being, advertisers can contribute to the healthy development of children and foster a positive and responsible advertising environment.

Privacy and Data Collection: Safeguarding children's personal information and privacy rights – this section addresses issues such as data collection in the digital age (Livingstone and Third, 2017), privacy concerns within social networking sites (Dwyer, et al., 2007), tracking practices by retailers (Turow, 2017), and interactive food and beverage marketing (Montgomery and Chester, 2009).

Livingstone and Third (2017) examine the challenges and implications of data collection in the digital age, particularly in relation to children and young people. They address the need to protect children's privacy rights and ensure ethical data collection practices that respect their autonomy and well-being. Another study explores privacy concerns within popular social networking sites, such as Facebook and MySpace, and discusses the potential risks associated with the collection and sharing of personal information (Dwyer, et al., 2007). It highlights the importance of safeguarding children's privacy rights within these online platforms. By

implementing ethical data collection practices and upholding privacy regulations, advertisers can ensure the confidentiality of children's personal information.

Cultural and Social Representations: Promoting inclusive and diverse representations, avoiding stereotypes and discrimination – this section highlights the positive impact of inclusive portrayals on consumer attitudes, brand perceptions, and societal attitudes. By incorporating inclusive representations and challenging stereotypes, advertisers can contribute to a more inclusive and diverse advertising landscape that reflects the values and diversity of society (Holt, 2016).

The cultural perception of play, including play with toys, can vary across cultures, ethnicities, and socioeconomic groups. For instance, play may be seen as central to the cognitive and social development of children in many technologically advanced Western countries, but less significant in more traditionalist societies (Roopnarine, 2010). Moreover, children from different cultures may have different frames of reference for gender-appropriate behaviors, as well as variations in cultural norms within their respective cultures (Pfeiffer and Butz, 2005). The choice of a particular toy is shaped by societal expectations, including how these toys are marketed both for purchase by parents and directly to children. Of course, the stereotypical marketing of toys reflects the choices made by marketing specialists about what customers are looking for and select, and these associations may be more or less grounded (Auster and Mansbach, 2012).

In highly developed societies, even very young children are left to play with objects and gadgets that promote the imitation of consumer models in a globalized society strongly influenced by modern technologies, reflecting numerous unresolved social issues (gender differences, multiculturalism, the pressure between structured and unstructured play) (Klemenovic, 2014). Understanding why a particular game or toy is successful can reveal a great deal about our culture's values and even more about the pressure exerted on families to possess certain objects, regardless of whether children desire them or not.

Responsible Advertising Techniques: Age-appropriate messaging, clear disclosures, avoiding aggressive or manipulative tactics - academic papers collectively emphasize the importance of responsible advertising techniques, including age-appropriate messaging (Nelson and Deshpande, 2004; Armstrong and Kotler, 2011, pp.604- 608), clear disclosures, and avoiding aggressive or manipulative tactics (Buijzen and Valkenburg, 2003). They highlight the potential consequences of inappropriate or deceptive advertising practices on children's decision-making, consumer perceptions, and overall well-being. By employing responsible advertising techniques, advertisers can ensure that their messages are suitable for the intended audience, provide clear and transparent information, and avoid manipulative tactics that may harm vulnerable individuals, such as children.

Nelson and Deshpande (2004) discuss the importance of age-appropriate messaging in advertising. It emphasizes the need for marketers to tailor their messages to the developmental stage of the target audience, taking into account their cognitive and emotional capabilities. Buijzen and Valkenburg (2003) examine the negative impact of aggressive and manipulative advertising tactics on children. They highlight the importance of avoiding such tactics and promoting responsible advertising practices that prioritize the well-being and development of children. Calvert and Wilson (2008, p.430) explore the impact of advertising on children, highlighting the presence of numerous advertisements promoting unhealthy products.

2. General Framework for Advertising to Children

This part presents an overview of the legislative framework for advertising children's products in the European Union, outlining the principles and objectives. Some of the issues discussed above are included in EU legislation and applied in Romania. However, aspects referred to

long-term emotional and cognitive development, stereotypes or materialism are much less regulated. The following sections illustrate the differences between Romanian legislation and other EU countries.

The main regulations in the European Union on the marketing of children's toys and games are related to the production of toys and games and how they prove safe for children. To be sold, they must comply with Directive 2009/48/EC. The essential safety requirements cover "physical and mechanical properties, flammability, chemical properties, electrical properties, hygiene and radioactivity". The technical details of toy safety requirements are specified in European standards (ec.europa.eu, n.d.). Advertisements for products aimed at children must ensure that they are honest and decent. When a toy is placed on the EEA market the manufacturer must draw up a CE declaration of conformity (Obelis, n.d.).

Directive on Unfair Commercial Practices (EUR-Lex, 2022) establishes rules regarding unfair commercial practices concerning consumers, including advertising to children. The Directive includes provisions for the protection of vulnerable consumers, including children, from misleading, aggressive or exploitative advertising that may manipulate children.

Audiovisual Media Services Directive (EUR-Lex, 2010) sets out rules for the welfare of audiovisual media services in the European Union, including advertising in mass media. The Directive contains specific provisions regarding advertising targeted at children, including restrictions on the promotion of certain products and services, limitations on the duration of advertising, and ensuring the protection of children from advertising that could harm their health, safety, or development.

European Commission (2012) provides the European Commission's recommendation regarding the welfare of children in advertising. It outlines the general framework for advertising to children, including principles such as promoting children's rights, protecting their physical and mental well-being, and ensuring that advertising respects their level of understanding and maturity.

The Committee of Advertising Practice (CAP, 2021) sets the guideline for advertising to children in the UK. It includes specific restrictions on advertising content, including toys and games, to ensure that they are appropriate for children's age group, do not encourage harmful behavior, and do not exploit their credulity, loyalty, or sense of adventure.

The general framework for advertising to children within the European Union has a few principles and objectives: 1.Restrictions on Advertising Content: The article examines specific restrictions on advertising content, such as limitations on advertising unhealthy foods or beverages to children; 2.Labelling and Disclosures: The importance of clear labelling and disclosures in advertising children's toys and games is discussed, along with relevant regulations in the European Union; 3.Promotional Techniques and Incentives: This section explores rules related to promotional techniques and incentives, such as giveaways, contests, and premiums, with a focus on protecting children from exploitative practices; 4.Online Marketing and Social Media: The article addresses the specific challenges and regulations associated with online marketing and social media targeting children, emphasizing the need to ensure their safety and privacy in the digital realm.

3. Marketing Regulations for Children's Toys and Games in Romania

This section examines the existing regulations in Romania concerning marketing toys and games to children. It provides an overview for the current regulatory landscape and highlights gaps or challenges.

In Romania (Portal Legislativ, 2008), specific references are made to advertising directed at children. It states that advertising aimed at children must be age-appropriate and respect human

dignity. Advertising must not exploit children's lack of experience or gullibility or encourage unhealthy or dangerous behaviors. Advertising should not affect the relationships that exist between minors, on one hand, and parents or educators, on the other hand. According to the law, advertising directed at children must not promote products or services that can harm their health, safety, development, or that can negatively influence their values and behaviors. It includes restrictions on advertising unhealthy food products and alcoholic beverages. Law no. 148/2000 also stipulates that advertising directed at children must not be deceptive or aggressive and must not exploit their naivety or gullibility. It must be clearly identified as advertising and not confuse or mislead children about its commercial nature.

The Audiovisual (Portal legislativ, 2002) regulates the audiovisual field, including advertising in the media. It contains provisions regarding the restrictions and rules applicable to advertising directed at children, such as the prohibition of advertising products that can harm children's health or safety. The law also imposes restrictions on advertising products that may affect the health or safety of children. For example, it includes the prohibition of advertising for unhealthy food products and alcoholic beverages targeted at children. The Code of Regulation for Audiovisual Content (CNA) (Portal legislativ, 2011) provides specific provisions regarding advertising for children. It establishes rules and guidelines for advertising in the audiovisual field. The code includes regulations on the content, presentation, and timing of advertisements targeting children. It highlights the need for age-appropriate messaging, clear disclosures, and the avoidance of aggressive or manipulative tactics in advertising directed at children. The CNA also restricts the promotion of certain products and services to children to protect their well-being, health, and developmental needs.

Although there is consensus within the European Union, Member States can adopt additional or stricter measures in national legislation to protect consumers, including children. Several EU governments have changed the law and imposed restrictions on advertising for games and toys. Sweden banned advertising to children on TV channels in 1996 (Cordes, 2000). Norway has followed Sweden's model, and Greece has partially restricted toy advertising between 7:00-22:00 (Buijzen and Valkenburg, 2003).

It is crucial that parents and educators receive effective media education. In a study conducted in the Romanian market to identify how ethics are perceived in marketing efforts for campaigns targeting children, although the parental dyads were parents of an average level of education, it resulted that notions of marketing ethics in general were extremely narrow, with most leaning towards the correct expression in campaigns of the product attributes and truths advocated by various organizations about the product offered (Aldea and Brandabur, 2015).

Richardson-Greenfield and La Ferle (2021) research delves into ethical and moral viewpoints of advertising practitioners through a series of comprehensive interviews. The study reveals that advertising practitioners recognize the necessity for ethical dialogues and education within their industry. They indicate the desire for more explicit guidelines, comprehensive training programs, and ongoing discussions to cultivate a heightened ethical advertising environment. Taking into account the perspectives and experiences of advertising practitioners is crucial for comprehending the ethical and moral aspects of the industry. The research offers valuable insights that can contribute to conversations on ethical decision-making, professional growth, and the advancement of ethical practices in advertising.

Drumwright and Murphy (2009) also provide a comprehensive overview of the current state of advertising ethics, incorporating insights from industry practitioners and academic researchers. It highlights the ongoing challenges in maintaining ethical standards in advertising and the need for continued dialogue, education, and collaboration between industry and academia to promote ethical practices in the field.

Conclusions

This research sheds light on the ethical considerations in marketing toys and games to children and the specific regulations governing such practices. By comparing the marketing regulations in Romania with those in other European Union states, the study identifies potential areas for improvement in the Romanian context. The proposed regulations and standards aim to enhance the ethics of marketing products to children, safeguarding their well-being and promoting responsible advertising practices. Future research and collaboration between the stakeholders are necessary to ensure a fair and ethical marketing environment for children in Romania and beyond.

The conclusion summarizes the main findings of the research, showing the importance of considering ethical aspects in marketing toys and games to children. It highlights the proposed regulations and standards as potential solutions to enhance the ethics of marketing products aimed at children. Further research is relevant for a fair and ethical marketing environment for children in Romania and beyond.

Acknowledgement(s): This work was co-funded by the European Social Fund, through Operational Programme Human Capital 2014-2020, project number POCU/993/6/13/153322, project title << Educational and training support for PhD students and young researchers in preparation for insertion into the labor market >>

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SECTION 4

SMARTEU SUMMER SCHOOL: STUDENT RESEARCH PAPERS

SUSTAINABLE URBAN DEVELOPMENT - IMPORTANCE AND CHALLENGES

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Abstract: The relationship between urban development and technological progress is mutually beneficial. Technological advancements meet the needs of citizens, leading to better, smarter cities. Conversely, cities function as concentrated hubs of economic activity and innovation, attracting skilled professionals, entrepreneurs, and investors who contribute to the deployment of cutting-edge technologies. For this cycle to stay virtuous, urban development must be supported by measures able to ensure operational, economic, environmental, and social sustainability. This paper highlights the importance of sustainable urban development and synthetizes the challenges associated with it, focusing on set of Internet-of-Things based projects implemented in three Romanian smart cities (Cluj Napoca, Iași and Alba-Iulia). The analyzed projects mainly support the Smart Mobility, Smart Environment and Smart Living dimensions of smart cities and are characterized by different degrees of operational, economic, environmental and social sustainability. Overall, the adoption of next-generation IoT solutions has the potential to revolutionize operations, drive economic growth, promote environmental sustainability, and enhance the social fabric of smart cities, ultimately improving the lives of individuals and the overall well-being of urban agglomerations.

Keywords: smart city, economic sustainability, operational sustainability, environmental sustainability, social sustainability, Internet of Things, projects

JEL classification: L86, M15

Introduction

The sustainable smart city is a city where the technological infrastructure creates, implements and supports operations to meet the growing needs of urbanization without negative economic, environmental and social impacts. In a smart city, technological progress is harmoniously and meaningfully incorporated into local governance, education, healthcare, energy, infrastructure, and mobility sectors (Padmaprya and Sujatha, 2021). Sustainable urban development is significant because of its long-term benefits, including increased revenue and enhanced quality of life, as well as reduced environmental impact. By funding initiatives that are sustainable, cities can create jobs and growth while simultaneously decreasing energy consumption, waste, and pollution. Additionally, sustainable development can improve living conditions and facilitate the social inclusion of various segments of society.

As cities grow larger and more populated, demand for urban infrastructure increases. When cities devote funds to innovative and practical sustainable methods, these methods can also become more environmentally friendly and efficient over time. This can have a significant impact on the environment, contributing both to the reduction of waste and energy

consumption. Additionally, through improving public transportation, cities can enhance the quality of air, reduce traffic congestion and noise pollution, and lower the cost of living for residents (Hager, 2023).

Moreover, sustainable urban development is vital to making sure all citizens can enjoy a better quality of life. Funding public projects and initiatives such as green areas, better transportation, and public safety, is beneficial for those on lower incomes, who would otherwise have difficulty participating in urban life, this will enhance their opportunities and provide them with a greater chance of mobility in the future (Rogridues and Lange, 2021). Also, in a city with a dynamic development, residents have greater access to employment and educational opportunities and increase their social status.

1. Literature review

The sustainable design of a smart city involves focusing on multiple perspectives, such as social, environmental, economic, cultural, and technological aspects. Economic, environmental, and social considerations are fundamental components of sustainable development in a smart city. People are at the center of smart cities, and technology plays an important role in accelerating and promoting sustainable development. The purpose of sustainable design in a smart city is to promote the harmonious and sustainable development of the „human-environment-society-economy-culture" ecosystem through careful planning (Gao, et al., 2023). There are several perspectives on sustainability in a smart city: economic, operational, social, and environmental (Ahvenniemi, et al., 2017; Aurigi and Odendaal, 2020; Lavalle, et al., 2020).

In the literature, the concept of *economic sustainability* is often defined as the ability of an economic system to respond to present requirements without compromising the ability of future generations to meet their own needs (Basiagio, 1999). This involves maintaining a balance between economic, social, and environmental aspects of development to promote sustainable and resilient growth. Economic sustainability also includes market growth, which implies creating an environment conducive to economic activity, entrepreneurship, and innovation. It emphasizes the importance of stable, inclusive, and balanced economic expansion that benefits both individuals and society. Another element targeted by economic sustainability is the creation of employment opportunities. Sustainable economic development aims to generate quality jobs that offer fair wages, decent working conditions, and opportunities for growth and advancement.

As a subset of economic sustainability, *operational sustainability* measures whether a business can maintain its existing practices without jeopardizing potential future resources. „Sustainable operations" can also be defined as operations that meet present needs without compromising the ability to meet future needs. The goal is to create supply chains that function well economically, socially, and environmentally (MBA Skool Team, 2013).

Social sustainability is defined as identifying and managing the positive and negative influences of systems, processes, organizations, and activities on people and social life (Balaman, 2018). It involves equitable access to quality services and facilities, social interaction and networks, public safety, participation in organized activities, a sense of pride and attachment to the community, and community stability (Dempsey, et al., 2011).

Environmental sustainability is defined as the capacity to improve the quality of human life within the limits of the planet's ecosystems' ability to sustain it (Evans, 2020). Environmental sustainability refers to the protection and conservation of the surrounding environment in a way that ensures the sustainable use of natural resources and reduces negative impacts on ecosystems and biodiversity. The goal is to maintain ecological balance and ensure that future generations have access to the same resources and benefits as the present ones.

Several authors emphasize the *role of IoT (Internet of Things) as a key technology in ensuring sustainable urban development*. IoT is primarily used to enhance profitability, maximize productivity, and minimize risks associated with human errors. Data obtained from IoT devices are utilized to improve communication between people and IoT processes, especially for developing applications in a sustainable smart city. Together with related technologies such as AI, 5G, and Blockchain, IoT drives the development of a green and sustainable smart city (Porkodi and Kesavaraja, 2021). According to Padmavathi and Aruna (2022), the true „intelligence" of a smart city lies in using IoT/M2M (Machine-to-Machine) communications in a structured, secure, responsible, and harmonized manner to fulfil the dreams and expectations of residents regarding sustainable development (Padmaprya and Sujatha, 2021). The security of the IoT sensor network, which forms the foundation of smart cities, is discussed in (Andrade, et al., 2021), where the authors highlight the importance of protecting IoT against DDoS (Distributed Denial of Service) and man-in-the-middle attacks, botnets, and social engineering. Padmaprya and Sujata argue that the successful implementation of sustainable smart cities requires a stable, secure, interoperable, and reliable telecommunications network to support applications and services in urban areas. Recent developments in IoT and Blockchain provide momentum and support for the advancement of sustainable smart cities (Padmaprya and Sujatha, 2021). Furthermore, the data collected through sensors must be usable by interested third parties, hence the condition of sustainability is to publish them as open data (Meschede and Siebenlist, 2021).

2. Data and Research methodology

After analyzing the smart city projects implemented in Cluj, Iași, and Alba Iulia, we selected the projects that used IoT as a technological solution. We considered all six traditional dimensions of smart cities as presented in the literature, sought projects focused on smart city development that incorporated IoT technologies, and examined the extent to which they supported sustainable development from operational, economic, social, and environmental perspectives. The chosen methodology for the proposed analysis involved accessing and researching relevant sources, such as the websites of local municipalities and public companies, local press, and specialized conferences. As a result of our research, we found that the projects identified in the three cities, based on Internet of Things technologies, were implemented only in three out of the six traditional dimensions mentioned, namely Smart Mobility, Smart Environment, and Smart Living. Their contribution to the sustainable urban development is discussed in the next section.

3. Results and Discussion

For the ***Smart Mobility dimension***, based on the analysis of the websites of local administration institutions in the three cities and articles from local and national press, we identified IoT projects in the following areas:

- Real-time positioning of vehicles used in public transportation - offer travelers up-to-date information on arrival times, optimal routes depending on the chosen departure point, possible delays, location of nearby stations, optimal routes depending on the chosen departure point, traffic alerts through electronic display and mobile apps;
- Micromobility solutions - electric scooters connected to the Internet (various private operators);
- Smart parking systems - parking spaces detection systems that transmit to a server the occupancy status of parking spaces in a certain area of the city;
- Smart pedestrian crossings;
- Traffic management solutions.

Table 1. IoT based smart city projects. Smart mobility dimension

Smart Mobility	Iași	Cluj-Napoca	Alba Iulia
Real-time positioning of vehicles used in public transport	Open data portal provided by GPS technologies, APIs; Tranzy, HereItIs, MooveIt - mobile application for dispatchers	Open data portal provided by GPS technologies, APIs; Tranzy, HereItIs, MooveIt, CTP Cluj- mobile application for dispatchers	50 buses equipped with real-time geolocation - currently functioning on 7 buses
Micromobility	The electric scooters use Bluetooth connections, Raspberry Pi computer boards, and SIM cards to connect to the internet, enabling them to communicate their location, distance traveled, battery life, and other relevant information		
Smart parking	970 active IoT parking sensors; UpPark mobile payment application	1309 (wireless) Parking Lot Sensors; CityParking/ClujParking real time parking spot finder app	50 IoT Parking Lot Sensors (made in Romania), mobile and Web apps, LoRa - piloted, non-functional; CityParking used in some areas of the city
Smart pedestrian crossings	Currently non-functional	20 overhead illuminated pedestrian crossings with LED technology poles	5 smart pedestrian crossings with integrated sensors and LED lights on poles
Traffic management solutions	88 intersections with adaptive traffic lights; 59 intersections with video monitoring; real-time video surveillance and analysis center; vehicle speed information panels; infrastructure with sensors and Wi-Fi backup system	Modern traffic light systems, video surveillance equipment, radars, acoustic devices, and traffic sensors are used to count pedestrians, detect red light crossings, and violations of speed limits	City Analytics: A platform for optimizing pedestrian traffic, people counting, and another solution for monitoring traffic volume at an important intersection - the solutions were functional, testing was completed, but currently they are non-functional

Sources: Panu, 2021; Nicolae, 2020; VegaComp Consulting, 2017; UPPARK, 2021; Grossman, 2021; SCTP Iași, 2023; Servus Cluj, 2023; Țimonea, 2022; Parry, 2021; Altimate, 2021

Regarding *real-time positioning of public transportation vehicles*, all analyzed cities have transport companies that have implemented GPS technologies to monitor and track the position of buses in real-time. This allows them to provide updated information to passengers regarding arrival times, routes, and possible delays through mobile applications (Tranzy, HereItIs, Moovit) that can also issue notifications and alerts regarding delays or route changes. From the perspective of operational sustainability, this solution has no negative impact on future resources and helps increase the accessibility and reliability of public transportation services. In terms of economic sustainability, as the solutions offer an open data infrastructure that

supports different types of applications, they create a competitive market for urban mobility applications. Public-private partnerships are also encouraged (such as the case of CTP - Wink in Iași). Knowing the real-time position of the vehicles allows for more accurate resource planning, thus reducing operational costs and promoting more sustainable economic management. Real-time vehicle positioning can contribute to improving services provided to customers. By providing accurate information about vehicle arrivals and departures, customer waiting times can be reduced, leading to increased customer satisfaction. By providing precise data, there is a possibility to increase the use of public transportation, which reduces the use of personal cars and air pollution, thereby enhancing environmental sustainability. In terms of social sustainability, real-time vehicle positioning is applicable to all citizens on public display screens at transport stations, accessible to everyone regardless of age, income, or education level. However, in the case of using mobile applications, digital divides might occur for certain groups.

Electric scooters have become increasingly popular in recent years due to their convenient and eco-friendly features. They can be used for short trips in urban areas, replacing personal cars or other means of public transportation. Regarding real-time positioning of electric scooters, existing rental companies like Lime and Bolt in Cluj, Iași, and Alba Iulia utilize GPS technologies to monitor and track the location of available scooters. Thus, users can access the specific rental company's application to see available scooters nearby for rental. From an operational sustainability perspective, electric scooters contain reusable parts that extend the service life and optimize resource usage. They are economically sustainable due to the use of a universal SIM based on IoT, making it easy to control network coverage, availability, and cost. The single SIM solution ensures that electric scooters can be used in every country, independent of local mobile phone operators, although international roaming charges for data usage can vary significantly and add to operational costs for scooter-sharing companies or end-users. In terms of environmental sustainability, according to the source li.me, an electric scooter trip uses 75% less carbon than the same trip taken by car. Additionally, each vehicle is powered by renewable energy. Concerning social sustainability, this service can only be accessed through applications and payment with cards, leading to cases of exclusion of certain groups based on income or access to digital solutions.

The proposed solution by the mentioned three cities for *monitoring parking spaces* and minimizing the time spent searching for their availability involves installing parking space detection systems that transmit the occupancy status of parking spaces in a certain area of the city to a server. The UpPark, Cluj Parking, and City Parking applications are based on a sensor network, depending on the geometry of the parking spaces, and an application with different interfaces for end-users and for the reference of the contracting authority managing these parking spaces. From an operational sustainability perspective, the sensor-based solution has no negative impact on future resources. On the economic sustainability side, municipalities collect higher parking fees, which optimize costs. The collected data can be used by different firms, and the sensors used in Alba Iulia for smart parking are produced by a Romanian company. For environmental sustainability, it is noteworthy that searching time for a parking space is reduced by up to 35%, leading to a decrease in carbon emissions. Smart parking can provide accessible parking spaces and designated features that cater to the needs of people with disabilities, promoting inclusion and equal access to parking facilities, supporting social sustainability. On the other hand, some citizens (elderly, people without adequate smartphone skills) may have limited access to applications.

Smart pedestrian crossings represent an evolution of traditional road infrastructure, integrating technology and interactive elements to ensure pedestrian safety during street crossings. These smart pedestrian crossings use sensors and other connected devices to detect the presence of pedestrians and communicate with drivers and traffic signal systems. From a management

perspective, operational sustainability is based on increasing the efficiency of both public and private transportation and improving traffic safety. This solution has a positive impact on economic activities by reducing waiting times and streamlining delivery, supply, and commuting activities. Regarding the environment, the reduction of congestion resulting from the IoT-based traffic management contributes to the reduction of carbon emissions through improved road efficiency. As an effect on society, through economic time saved in travel, the quality of life for drivers and passengers is increased, while stress associated with traffic flow is reduced.

Following the analysis of ***projects that use IoT for environmental sustainability***, the following solutions have been identified in the analyzed cities:

- Air quality monitoring solutions;
- Energy management - measuring voltage levels, frequency, interruptions in the public lighting system + reporting, alerting, intelligent maintenance functions;
- GPS monitoring of the waste collection fleet;
- Smart waste collection bins.

All these solutions are presented in Table 2.

Table 2. IoT based smart city projects. Smart environment dimension

Smart Environment	Iași	Cluj-Napoca	Alba Iulia
Air quality monitoring solutions	In all three 3 cities, sensors capable of monitoring suspended particulate matter (PM1, PM2.5, and PM10), air pressure, temperature, humidity, and carbon dioxide levels are installed. These sensors enable real-time monitoring and data collection related to air quality and environmental conditions in the urban areas, helping to assess and address environmental concerns and promote sustainable practices.		
Energy management	N/A	N/A	Box2M -a technological ecosystem consisting of industrial IoT equipment and specialized software applications. It is designed for use in public energy and utility networks, enabling real-time monitoring, data collection, and analysis
GPS monitoring of the waste collection fleet	The use of GPS technology to track and monitor Salubris' fleet of waste collection vehicles and street sweepers.	Equipping all waste collection vehicles with GPS-based monitoring systems.	N/A
Smart waste collection bins	The garbage bins are equipped with advanced technologies and IoT solutions to optimize waste collection and monitoring.		

Sources: Trufașu, 2022; Orange, 2018; Salubris, 2023; Ziua de Cluj, 2019; Redacția Alba24.ro, 2022; Cîmpean, 2022

The *air quality measurement solutions* collect data through sensors, process them and send the information via Wi-Fi to multiple platforms, making it available online to any citizen concerned about air quality. Pollution levels can then be compared with the limit values set by the European Union or used to estimate possible cases when the air becomes hazardous for the population. Although their economic impact is not significant, projects of this kind have a positive impact on the environment by increasing awareness of pollution and providing useful data for decision-making by local authorities. They address all city residents without discrimination, helping to limit the level of pollutants to which they are exposed.

Box2M has implemented an electric *energy management solution* in Alba-Iulia. The primary transmission is done through the LTE-M Orange network, and there is a secondary transmission through GSM. The Box2M system facilitates quick recognition of phenomena such as power phase imbalances in the public lighting system, caused by uneven load in different stages of system development, or exceeding standard parameters of power quality, especially during certain time intervals, which can directly affect the operation of connected equipment. It also easily provides energy management reports with low granularity, crucial for highly accurate consumption estimates and reducing energy purchase costs. The data can be viewed by administrators in the Live Objects platform or aggregated with other solutions in the dedicated application, Smart Territories, both offered by Orange (Orange, 2019; Orange, 2018). Operational sustainability of this solution is evident - by collecting precise data about the operation of the power supply network, its performance is improved by adjusting supply based on consumption patterns and various imbalances. The economic impact is related to reduced electricity costs, which is also positive in terms of its effects on the environment.

In the past year, SC Salubris SA Iași has modernized its control center through investments in powerful and efficient hardware and software. The centerpiece of this development is a robust monitoring system for garbage trucks, based on a GPS application. This monitoring system has made possible the creation an interactive map available on the website www.salubris.ro, which can be used to monitor household collection points and garbage trucks via GPS (Miron, 2021). This solution is also present in Cluj Napoca, where all waste collection vehicles are equipped with GPS, and their routes can be tracked in real-time on the city's website (Mureșan, 2019). Additionally, smart trash bins are present in all three analyzed cities and involve the use of advanced technologies and IoT solutions to optimize waste collection and monitoring. The sensors can detect when a container is full or nearly full, allowing for efficient scheduling of waste collection. Information about the waste level can be transmitted to local authorities or waste management companies, where the data collected by sensors in the bins can be used to generate reports and analyses about waste generation trends. The collected, interpreted, and utilized data ensures operational sustainability by effectively using current resources without negatively impacting future ones. From an economic standpoint, costs are reduced by optimizing waste collection routes. Timely waste collection reduces negative environmental impact while also increasing citizen satisfaction.

For the *Smart Living dimension*, following the analysis of the websites of local administration institutions in the three cities and articles from local and national press, we have identified IoT projects in the following areas:

- Smart lighting;
- Public safety (monitoring of different areas in the city);
- Smart residential complexes and buildings.

Table 3. IoT based smart city projects. Smart living dimension

Smart Living	Iași	Cluj-Napoca	Alba Iulia
Smart lightining	Public lighting with high-energy efficiency LED lamps, long lifespan, and low consumption, remote management of public lighting at the level of lighting fixtures and ignition points, logical interconnection of the lighting system with the traffic management system and local weather stations	Replacement of existing lighting fixtures and support arms with LED lighting fixtures, new support arms, and implementation of a remote management system. 101 poles equipped with controllable LED lights (dimming feature) integrated into the LoRaWAN system, provided by Orange	„Mihai Eminescu" School in Alba Iulia - better quality of light, modulation according to daylight, sensors in corridors and bathrooms
Public safety	CCTV		
Smart residential complexes and buildings	Automation technology for the main building systems (HVAC - Heating, Ventilation, Air Conditioning, energy, ITC, security, lighting, safety), temperature and humidity sensors, smart meters, smart thermostats, video surveillance with automatic image processing capability	Transilvania Smart City - a residential complex with incorporated smart features	N/A

Sources: InfoRegio Nord-Est, 2020; Actual de Cluj, 2022; Orange, 2016; Andrei, 2020; Primăria Cluj-Napoca, 2010; Panu, 2021; Piatra Online, 2022

Smart lighting refers to the use of IoT to control and manage lighting solutions in a more efficient and flexible manner. Smart lighting systems utilize sensors, control devices, and communication networks to enable monitoring and individual control of each light source or group of light sources. As presented in table 3, all analyzed cities have implemented this smart solution. From an operational perspective, sustainability is based on modernization, resulting in a decrease in annual primary energy consumption in public lighting, supporting economic sustainability. For environmental sustainability, it reduces greenhouse gas emissions. From a social perspective, all citizens can benefit from smart lighting solutions.

All three mentioned cities have adopted CCTV monitoring to enhance *public safety* and observe real-time traffic, public areas, and public transportation. Operators monitor the video flow and look for red flags or suspicious behavior. If an unusual situation is detected, appropriate actions can be taken immediately. CCTV monitoring leads to better use of existing infrastructure, with economic effects in terms of cost savings through prompt interventions

where needed. The impact on the environment may not be readily visible, but the social effects are positive.

Residential smart buildings represent an advancement in construction technology, integrating various smart systems and devices to provide a more comfortable, efficient, and secure environment, as presented in the previous table. The project in Cluj Napoca is divided into five stages, and the first phase provides future residents with all the amenities of smart homes (Piatra Online, 2022). Although investments in smart home projects may not be negligible, and issues related to data security and device compatibility may arise, in the long run, these solutions can prove to be economically sustainable. With reduced utility consumption, the impact on the environment is positive. However, these solutions are not accessible to all citizens due to cost barriers and digital literacy.

Conclusions

The categorization of IoT projects into dimensions is a debatable aspect and can be amended based on the specificities of each project. In general, IoT projects are not limited to a single dimension but often support and target multiple aspects of smart city development.

Both the public and private sectors can play a significant role in the development and implementation of IoT projects in smart cities. Partnerships are essential for the sustainable development of smart cities as they involve cooperation and collaboration among different entities, including public authorities, private companies, higher education institutions, and local communities. Sometimes, partnerships may encounter difficulties in maintaining commitment, coordinating efforts, and ensuring the necessary resources for implementation. These difficulties can lead to project disruptions and lack of continuity, as highlighted in the analysis of Alba Iulia.

Although we have identified substantial European funding for public lighting projects in Iași and Cluj Napoca, the access to external public funds for smart city development projects is very limited. We have identified only one IoT project for smart cities funded under the European Union's Horizon 2020 program: CloudUT, implemented by the Technical University of Cluj-Napoca.

The adoption rate of IoT is rather low. Conditions for development include the deployment of 5G, a legal framework, public-private collaboration (Cepăreanu și Cornea, 2023), and coherent strategies (Iași sets a good example). The beginning has been made, but even in the top 3 smart cities in Romania, IoT-based development projects are few. The failure rate for such projects, as demonstrated by the case of Alba Iulia, is very high.

From an operational perspective, the adoption of next-generation IoT solutions can have the same transformative impact as the high-speed optical fiber. The versatility of IoT use cases extends beyond the private sector and can be applied effectively in smart cities. IoT projects offer substantial economic potential and contribute to the sustainable development of smart cities. As the adoption of IoT technologies increases, these projects can stimulate and benefit numerous economic sectors. The interconnectedness and data-driven nature of IoT enable innovative business models, create new job opportunities, and drive economic growth. The positive impact of IoT-based projects on environmental sustainability is evident. By implementing IoT technology across urban life, resource consumption can be reduced, carbon emissions minimized, and a cleaner, healthier environment promoted. IoT-enabled systems optimize energy usage, facilitate efficient waste management, and enable smart transportation, thus supporting the goal of creating sustainable and eco-friendly cities. In terms of social impact, most IoT projects are highly inclusive and accessible, benefiting all citizens of smart cities without discrimination. The widespread availability and affordability of IoT solutions enhance the quality of life in urban areas. Smart infrastructure, IoT-enabled healthcare systems,

and advanced public services improve accessibility, convenience, and safety for residents, fostering a more inclusive and livable urban environment.

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INSIDE THE WORLD'S MOST SUSTAINABLE SMART CITY: LESSONS FROM COPENHAGEN

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Abstract: Smart city emerged as a new approach to urban development, aiming to bring innovative solutions to the complex challenges that cities face today. A general objective of the smart city agenda is to achieve sustainability through the use of technological instruments, best practices coming from Western cities. Copenhagen has earned a reputation as the world's most sustainable smart city due to its commitment to sustainability practices and policies. This qualitative research article analyses Copenhagen's sustainability practices and policies based on a comprehensive document analysis of reports, official websites, and academic papers. The study aims to identify the drivers behind Copenhagen's success and to draw lessons for other cities seeking to become sustainable. The article examines Copenhagen's sustainability practices in the areas of renewable energy, green infrastructure, and sustainable transportation. The research draws on these experiences to identify key lessons for other cities, highlighting the importance of political commitment, stakeholder engagement, and long-term planning for sustainability.

Keywords: sustainability, smart city, sustainable practices, urban policies

JEL Classification: O13, O18, Q01, Q20, Q28, R11, R58

Introduction

Copenhagen, the capital of Denmark and the largest city in the country, is a city founded in the year 1160, nowadays being a "leading model on urban sustainability" (Ramos, 2021), experts considering it being the "world's greenest city", title awarded in the year 2017 (Ramos, 2021). Copenhagen, the capital city of Denmark, stands as a shining example of a smart city, where innovation, sustainability, and quality of life intersect. With its forward-thinking approach and comprehensive strategies, Copenhagen has successfully established itself as a global leader in the realm of smart urban development.

At the heart of Copenhagen's smart city initiatives is its commitment to sustainability. The city has set ambitious goals to become carbon-neutral by 2025, driving the adoption of renewable energy sources and energy-efficient technologies. Wind and solar power are extensively harnessed to power the city's infrastructure, including public transportation, street lighting, and buildings. Copenhagen actively promotes cycling as a sustainable mode of transport, with an extensive network of bike lanes and dedicated infrastructure that encourages residents to embrace eco-friendly transportation options (Brynskov, et al., 2018). Transportation plays a vital role in Copenhagen's smart city framework. The city's public transportation system is well-connected and efficient, offering buses, trains, and an extensive metro network. Real-time data and digital platforms provide commuters with up-to-date information on routes, schedules,

and congestion, empowering them to make informed choices for their journeys. Copenhagen's emphasis on cycling infrastructure, coupled with bike-sharing programs and electric vehicle incentives, promotes sustainable mobility and reduces traffic congestion (Verbeek, 2016).

Copenhagen's smart city initiatives extend beyond infrastructure and mobility. The city actively engages its residents in decision-making processes, encouraging citizen participation and fostering a sense of ownership. Digital platforms and mobile applications allow citizens to access real-time data on various aspects of the city, such as air quality, energy consumption, and public transportation (Garfield, 2017). This transparency empowers residents to make informed choices, contribute to urban planning, and actively participate in shaping their communities. The city's dedication to sustainability extends to waste management as well. Copenhagen has implemented advanced waste collection systems, utilizing underground vacuum tubes to transport waste directly to recycling centers. Smart sensors and data analytics optimize waste collection routes, ensuring efficient and timely disposal while minimizing environmental impact. By promoting waste reduction, reuse, and recycling, Copenhagen cultivates a circular economy that minimizes resource consumption and waste generation.

In terms of architecture and urban planning, Copenhagen leverages digital technologies and data-driven insights to design energy-efficient buildings, optimize urban spaces, and enhance safety. Smart sensors and monitoring systems ensure optimal resource usage, such as water and electricity, while also improving safety and security. The city embraces intelligent lighting solutions that adapt to environmental conditions, promoting energy efficiency and enhancing public safety. Copenhagen's commitment to collaboration and innovation is also notable. The city actively collaborates with academic institutions, research organizations, and industry leaders to drive technological advancements and share best practices. This collaborative approach facilitates the development of cutting-edge solutions to urban challenges and fosters a vibrant startup ecosystem focused on smart city innovations.

1. Literature review

The development of smart cities can be linked to the *future cities* discourse and can be traced back to the post-WWII era. The idea of integrating technology into mainstream urban planning practices became popular among economists, planners and sociologists, supporting knowledge and innovation (Angelidou, 2015), while a plethora of concepts and ideas can be associated with the future city. The *sustainable city* discourse was introduced in the 1990s, in light of the Brundtland Commission's publication on sustainable development (de Jong, et al., 2015) and gained more attention in recent years due to the urgency of environmental challenges across the world (Moir, et al., 2014). Often linked to the 'eco city' and the 'green city' concepts, the 'sustainable city' projects the opportunity to create better environmental, social and economic conditions in urban areas. Closely related to sustainability, the 'resilient city' emphasizes the ability of cities to adapt and transform in response to changing circumstances, yet lacking the technological dimension.

In the last years we have experienced an extreme growth in terms of information and communication technologies (ICTs) and the massive use of ICTs in cities, regardless of the form in which they are used, has led to the appearance of labels such as "cyberville", "digital city", "telecity", "information city" and also "smart city" (Mohanty, 2016). Emerged as a more advanced form of the abovementioned concepts, the smart city incorporates technological instruments, elements of sustainability and quality of life (Neirotti, et al., 2014) aiming to tackle urban challenges through innovative solutions. In this context, the smart and sustainable dimensions are often intertwined, both addressing citizens' well-being, environmental responsibility, service efficiency and economic growth (Bibri & Krogstie, 2017).

A smart city is a concept that has gained significant attention in recent years as cities around the world strive to become more efficient, sustainable, and livable, being introduced in 1994 (Dameri & Cocchia, 2013). There is no single, universally accepted definition of a smart city, but the term generally refers to a city that uses technology and data to improve the quality of life for its residents, enhance its infrastructure, and promote economic growth.

One of the earliest definitions of a smart city was proposed by IBM in 2009, which defined it as "an urban environment that leverages information technology to improve the quality of life for its citizens, enhance sustainability, and reduce waste" (IBM Institute for Business Value, 2009). Since then, many other definitions have emerged, each with its own focus and emphasis.

There has been a growing body of literature on smart cities, with researchers and practitioners exploring different aspects of the concept, from governance and policy to technology and innovation. Another definition paints the smart city as "A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens" (Giffinger, et al., 2007). The smart city is also seen as representing "a community of average technology size, interconnected and sustainable, comfortable, attractive, and secure. A smart city is a city well performing in 6 characteristics. These characteristics are built on the smart combination of endowments and activities of self-decisive, independent and aware citizens" (Lazaroiu & Roscia, 2012). Even though there isn't an unanimous definition for a smart city, "The various positions in the debate agree on the fact that an SC should be able to optimize the use and exploitation of both tangible (e.g. transport infrastructures, energy distribution networks, natural resources) and intangible assets (e.g. human capital, intellectual capital of companies, and organizational capital in public administration bodies)" (Neirotti, et al., 2014). Some of the key themes that have emerged include the importance of citizen engagement and participation, the need for effective data management and analytics, and the challenges of ensuring equity and inclusion in the development of smart city initiatives. Overall, the literature suggests that while smart city technologies hold great promise, they must be carefully deployed and managed to ensure that they serve the needs of all citizens and promote a more sustainable and resilient urban future.

Regarding the concept of "sustainable development" it is clear that it formed by attaching the words "sustainability" and "development". Sustainable development and sustainability are two phrases more and more common nowadays, being a real "buzzword". Authors consider sustainable development as being "development that can be continued either indefinitely or for the given time period" (Stoddart, et al., 2011), but the most cited definition is the one from the Brundtland Commission Report: "development that meets the needs of the current generation without compromising the ability of future generations to meet their own needs" (Schaefer & Crane, 2005). Other authors say about sustainable development that it is "a core concept within global development policy and agenda" (Abubakar, 2017).

Sustainable development implies three dimensions, three pillars: the economic one, the social one and the environmental one. This means that in order to comply to the sustainable development agenda, "the best choices are those that meet the needs of the society and are environmentally and economically viable, economically and socially equitable as well as socially and environmentally bearable" (Porter & van der Linde, 1995).

The importance of interconnecting the three pillars in order to have the best results is highlighted in the following case: "If a man in a given geographical area lacks a job (economic), he is likely to be poor and disenfranchised (social); if he is poor and disenfranchised, he has an incentive to engage in practices that harm ecology, for example, by cutting down trees for firewood to cook his meals and warm his home (environmental). As his actions are aggregated with those of others in his region cutting down trees, deforestation will cause vital minerals to

be lost from the soil (environmental). If vital minerals are lost from the soil, the inhabitants will be deprived of the dietary nutrients required to sustain the intellectual performance needed to learn new technologies, for example, how to operate a computer, and this will cause productivity to reduce or stagnate (economic). If productivity stagnates (economic), poor people will remain poor or poorer (social), and the cycle continues" (Basiago, 1999).

Lastly, a concept used in the literature is "sustainable smart city", combining both concepts mentioned before, smart city and sustainability or sustainable development. It is defined as „an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operations and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects" (Mohanty, 2016). The concept of a sustainable smart city builds on the idea of a smart city, but with a greater focus on environmental sustainability and social equity.

A sustainable smart city seeks to leverage technology and data to improve quality of life for residents, while also reducing its environmental footprint and promoting social and economic equity. In recent years, there has been a growing recognition that the pursuit of smart city initiatives must be coupled with a commitment to sustainability. This has led to a focus on initiatives that promote renewable energy, energy efficiency, sustainable transportation, waste reduction, and other environmental goals. The literature on sustainable smart cities emphasizes the importance of integrating sustainability considerations into all aspects of smart city planning and development (Ahvenniemi, et al., 2017). This requires collaboration between government, industry, and civil society, as well as a focus on equity and social justice. For example, sustainable smart city initiatives should be designed to benefit all residents, regardless of income level or social status. Overall, the concept of a sustainable smart city represents a promising vision for the future of urban development, one that prioritizes both technological innovation and environmental sustainability in pursuit of a more livable, equitable, and resilient urban future.

2. Research methodology

This study employs a qualitative research design to explore the sustainable practices of Copenhagen, one of the most developed smart cities in the world. The research design is based on document analysis, which involves collecting, analyzing, and interpreting data from various documents related to Copenhagen's sustainability policies and practices.

The primary data sources for this study are documents related to Copenhagen's sustainable policies and practices. These documents include official reports, policy papers, research articles, and other publications related to sustainable development in Copenhagen. We will gather these documents from online databases, official websites, and other relevant sources. We will conduct a content analysis of the collected documents. This analysis involves identifying and categorizing themes, patterns, and trends related to sustainable development in Copenhagen. We will use qualitative data analysis software, such as NVivo, to manage and analyze the data.

The researchers will ensure that ethical principles are upheld throughout the research process. This includes obtaining necessary permissions to access and use the documents, maintaining confidentiality and anonymity of the sources, and ensuring that the study does not cause harm to any individual or group.

One of the limitations of this study is the reliance on secondary data sources. The researchers have no control over the accuracy and completeness of the documents collected. Additionally, the study only focuses on Copenhagen, and the findings may not be generalizable to other cities.

3. Results

3.1. Smart Mobility

The starting point in terms of mobility was in 1847 when the first railroad was constructed in Copenhagen, but in the 18th hundreds a new possibility appeared, which is still very actual, the "safety bicycle model" (Schmidt & Jørgensen, 2016). It was said that "The bike could go anywhere, from door to door, was independent of routes and travel times, should not be fed, was more effective than walking, and it proved to be faster than most other forms of transport" (Jensen, 1981). Nowadays, Copenhagen is known for its efficient and sustainable mobility system, making it one of the most bike-friendly cities in the world. Copenhagen is a city of cyclists, with over 62% of the population commuting by bike. There are dedicated bike lanes on most roads, and the city has a bike-sharing system, which allows residents and visitors to rent bikes easily. Copenhagen also has an extensive public transport system, including buses, trains, and metro lines. The public transport network is well-integrated and operated by a single company, making it easy to navigate. Walking is also a popular mode of transport in Copenhagen, with many streets and neighborhoods designed for pedestrian use. The city also has several walking tours available to visitors, which showcase the city's history and culture. While Copenhagen does have some car traffic, it is relatively low compared to other major cities. Parking in the city center can be difficult and expensive, and there are many areas where cars are restricted or prohibited. Copenhagen also has a range of other transport options, including electric scooters, water buses, and even a ferry service to Sweden.

In terms of mobility, Copenhagen City Council has previously formulated a set which contains twenty-five initiatives for a green mobility (Action plan for Green Mobility, 2013) and those initiatives required an investment around 160 million euros. In one report made by Deloitte, the mobility of Copenhagen was analyzed, and some interesting insights were provided. In terms of mobility choice, 26% of the transportation is made of private cars, 27% of public transportation, 6% of walking and 41% of bicycles (Deloitte Insights, 2019). The report also shows some strengths and challenges in terms of smart mobility. Some of the main strengths are: "Copenhagen is one of the world's most bicycle friendly cities, commuters' cycle 1,1 million kilometers daily". It is also known for its "extensive public transit system which includes intermodal transfer system and integrated ticketing options". Moreover, "the city supports open data and promotes digital solutions to tackle traffic, the environment and urban planning". On the other side, the one of challenges, the 2019 reports highlights the followings: "air quality remains a challenge with higher levels of nitrogen oxides due to diesel vehicles, the bike lanes reach capacity at peak times and bike traffic is set to grow 25% by 2025 and the city needs to find ways to ensure access for all road traffic while prioritizing cycling" (Deloitte Insights, 2019).

Smart mobility in Copenhagen is an integral part of the city's commitment to sustainability, efficiency, and quality of life. The Danish capital has established itself as a global leader in promoting innovative and intelligent transportation solutions. At the heart of Copenhagen's smart mobility initiatives lies the vision of creating a city that prioritizes people-centric, environmentally friendly, and technologically advanced transportation systems. Copenhagen's smart mobility strategy embraces a multimodal approach, encouraging residents and visitors to choose sustainable modes of transport. Cycling plays a central role in the city's transportation system, with an extensive network of dedicated bike lanes and infrastructure. This commitment to cycling has created a culture where bicycles are the preferred mode of transportation for many Copenhageners, resulting in reduced traffic congestion, improved air quality, and enhanced public health (Copenhagen City of Cyclists).

To complement cycling, Copenhagen offers an efficient and well-connected public transportation system. Buses, trains, and metro lines provide comprehensive coverage, enabling seamless

connectivity throughout the city and its surrounding areas. Real-time information systems and mobile apps ensure that commuters have up-to-date information about routes, schedules, and service disruptions, facilitating smooth and hassle-free travel. In addition to conventional modes of transportation, Copenhagen actively promotes the use of electric vehicles (EVs) to reduce emissions and combat climate change. The city has invested in expanding EV charging infrastructure, making it convenient for EV owners to recharge their vehicles. Furthermore, incentives such as reduced parking fees and access to dedicated lanes encourage the adoption of electric cars and support the transition to a cleaner and more sustainable transport system (State of Green).

Copenhagen's smart mobility efforts extend beyond individual modes of transport. The city utilizes advanced data collection and analysis techniques to optimize transportation networks and improve traffic flow. Intelligent traffic management systems monitor real-time traffic conditions and adjust signal timings, accordingly, reducing congestion and travel times. This data-driven approach enables authorities to proactively address traffic issues, minimize bottlenecks, and enhance overall transport efficiency.

To encourage the shift towards sustainable transportation choices, Copenhagen leverages digital platforms and applications. Journey planning apps provide commuters with personalized route suggestions, considering factors such as distance, mode of transport, and real-time traffic conditions. Moreover, shared mobility services, including bike-sharing and car-sharing programs, offer convenient alternatives to car ownership, promoting flexibility and reducing the number of private vehicles on the road.

Citizen engagement is a key element of smart mobility in Copenhagen. The city actively involves residents in decision-making processes, soliciting feedback and ideas to shape transportation policies and infrastructure development. Through participatory platforms and public consultations, Copenhageners can contribute to the ongoing evolution of the city's smart mobility landscape. Copenhagen's commitment to smart mobility is further demonstrated by its emphasis on research, innovation, and collaboration (Lu, et al., 2019). The city collaborates with universities, research institutions, and private partners to develop and test cutting-edge technologies, such as autonomous vehicles, smart traffic management systems, and mobility-as-a-service (MaaS) platforms. This collaborative approach ensures that Copenhagen remains at the forefront of smart mobility solutions, continuously evolving and adapting to the changing needs of its residents.

In summary, smart mobility in Copenhagen encompasses a holistic and forward-thinking approach to transportation. By prioritizing cycling, investing in public transportation, promoting electric vehicles, utilizing data-driven optimization strategies, and engaging citizens, Copenhagen has created a sustainable, efficient, and people-centric transportation ecosystem that serves as a model for cities around the world.

3.2. Smart Environment

Copenhagen, the capital of Denmark, has made remarkable strides in transforming itself into a smart environment that prioritizes sustainability, efficiency, and quality of life for its residents. This progressive city has embraced cutting-edge technologies and innovative solutions to create a seamless integration of digital systems and urban infrastructure. By leveraging data, connectivity, and citizen engagement, Copenhagen has successfully established itself as a global leader in smart urban development.

One of the key pillars of Copenhagen's smart environment is its commitment to sustainability. The city has set ambitious goals to become carbon-neutral by 2025, and various initiatives have been implemented to achieve this objective. Renewable energy sources, such as wind and solar power, are extensively utilized to power the city's infrastructure, including public

transportation, streetlights, and buildings. Energy-efficient technologies, such as smart grids and intelligent lighting systems, are deployed to optimize energy consumption and reduce waste (Hansen, et al., 2017). Transportation plays a vital role in Copenhagen's smart city framework. The city has prioritized cycling as a sustainable mode of transportation, with an extensive network of bike lanes and dedicated cycling infrastructure. To facilitate this, Copenhagen employs smart solutions like bike-sharing programs and real-time traffic monitoring systems to enhance traffic flow and promote eco-friendly transportation options. Moreover, the city actively encourages the use of electric vehicles by providing charging infrastructure and offering incentives for their adoption.

Copenhagen's smart environment extends to waste management as well (Duque-Ramos & Varga, 2018). The city has implemented a comprehensive waste collection system that employs underground vacuum tubes to transport waste directly to recycling centers, reducing the need for traditional waste collection trucks and minimizing pollution. Smart sensors and data analytics are utilized to optimize waste collection routes, ensuring efficient and timely disposal while minimizing environmental impact.

Another noteworthy aspect of Copenhagen's smart environment is its emphasis on citizen engagement and participation. The city actively involves its residents in decision-making processes, using digital platforms and mobile applications to gather feedback and ideas for improving urban life (Borup Lynggaard & Bagger-Petersen, 2019). Citizens can access real-time data on various aspects of the city, such as air quality, energy consumption, and public transportation, empowering them to make informed choices and actively contribute to a sustainable and livable city. Copenhagen's smart environment has also revolutionized its urban planning and architecture. The city leverages digital technologies and data analytics to design energy-efficient buildings, optimize urban spaces, and create intelligent infrastructure. Smart sensors and monitoring systems are employed to ensure optimal use of resources, such as water and electricity, while also enhancing safety and security (Neirotti, et al., 2014). Additionally, Copenhagen's smart city initiatives have fostered a vibrant startup ecosystem, attracting innovative companies and entrepreneurs focused on developing solutions for urban challenges.

To support its smart environment vision, Copenhagen has cultivated partnerships with academic institutions, research organizations, and industry leaders. Collaborative projects and initiatives are undertaken to foster innovation, drive technological advancements, and share best practices with other cities around the world. This collaborative approach (Hall & Bowerman, 2016) enables Copenhagen to stay at the forefront of smart urban development and continually evolve its strategies to meet the evolving needs of its citizens.

In conclusion, Copenhagen's smart environment represents a remarkable integration of sustainability, technology, and citizen engagement. By embracing smart solutions in areas such as energy, transportation, waste management, and urban planning, the city has created a model for other cities to follow. With its commitment to innovation and collaboration, Copenhagen continues to push the boundaries of what is possible in creating a livable, resilient, and sustainable urban environment.

3.3. Smart Living

Smart living in Copenhagen represents a holistic approach to creating a connected, efficient, and sustainable lifestyle for its residents. The city has embraced technological advancements and innovative solutions to enhance the quality of life, promote well-being, and foster a sense of community among its inhabitants (Bibri, 2018). Through a combination of smart infrastructure, digital services, and citizen-centric initiatives, Copenhagen has redefined urban living by putting people at the center of its smart city vision.

One of the key aspects of smart living in Copenhagen is the emphasis on sustainable and energy-efficient housing. The city has implemented stringent building standards that promote eco-friendly construction practices and the use of renewable energy sources (Andersen, et al., 2017). Energy-efficient technologies, such as smart meters and home automation systems, are integrated into residential buildings, allowing residents to monitor and optimize their energy consumption. Furthermore, Copenhagen encourages the adoption of green building materials, such as solar panels and green roofs, to reduce carbon emissions and create a healthier living environment.

Smart living in Copenhagen extends beyond the physical infrastructure and transportation systems. The city leverages technology to enhance the well-being and livability of its residents. Digital platforms and mobile applications provide access to a wide range of services, including healthcare, education, and cultural events (Kjærgaard, et al., 2015). Citizens can conveniently access medical advice, book appointments, and receive personalized healthcare information through telemedicine solutions. Similarly, online learning platforms and digital educational resources facilitate lifelong learning and empower residents to acquire new skills and knowledge. Furthermore, Copenhagen's vibrant cultural scene is amplified through digital platforms, allowing residents to explore and participate in various artistic and community events (Borup Lynggaard & Skouby, 2020).

Safety and security are paramount in smart living, and Copenhagen leverages technology to ensure the well-being of its residents. Smart surveillance systems, including CCTV cameras and sensors, are strategically placed to enhance public safety and deter crime (Kjærgaard, et al., 2015). Emergency response systems are integrated with real-time data and analytics to provide efficient and effective emergency services. Additionally, Copenhagen employs smart lighting solutions that adapt to the environment, improving visibility and enhancing the feeling of safety in public spaces.

Copenhagen's commitment to sustainability extends to waste management and resource optimization. The city employs smart solutions to optimize waste collection routes, reduce landfill waste, and promote recycling. Underground waste collection systems and smart bins equipped with sensors optimize waste disposal, minimizing environmental impact and enhancing cleanliness (Neirotti, et al., 2014). Furthermore, Copenhagen encourages residents to reduce, reuse, and recycle through awareness campaigns and incentives, fostering a culture of responsible consumption and waste reduction.

In conclusion, smart living in Copenhagen represents a transformative approach to urban living that prioritizes sustainability, connectivity, and citizen well-being. By integrating technology, infrastructure, and citizen engagement, the city has created an environment where residents can enjoy a high quality of life while minimizing their ecological footprint. Copenhagen's commitment to innovation, sustainability, and community.

3.4. Smart People

Smart people is an essential component of smart cities as it can ensure sustainable long-term growth of initiatives. Copenhagen is known for its highly educated and innovative population which plays a significant role in the city's smart and sustainable development. With a well-developed education system, several world-class research institutions and universities, the city supports continuous learning and innovation among its citizens. Copenhagen's research and innovation ecosystem facilitates advancements in science, technology and humanities, attracting scholars, researchers and students through fundings, collaboration opportunities and infrastructure (The City of Copenhagen, 2022). Moreover, the city recognizes the importance of lifelong learning through adult education training opportunities, cultural institutions and professional development. Thus, programs, workshops and courses are available for

individuals seeking to enhance their skills, gain knowledge or explore new areas of interest. To improve the quality and accessibility of education, the municipality has developed various initiatives and projects across the city. Schools in Copenhagen have adopted an anti-bullying strategy through which they protect vulnerable children and provide safe and tolerant environments for pupils.

Copenhagen offers a dynamic and diverse employment environment, having a relatively low unemployment rate compared to many other cities. The municipality's focus on innovation, education and sustainability has supported job creation and economic growth, as well as favorable conditions for residents and newcomers. Named the top city in the world for a healthy work-life balance (Forbes, 2023), Copenhagen promotes flexible working hours arrangements and prioritizes the wellbeing of residents.

In terms of social cohesion, Copenhagen prioritizes inclusive policies that promote equality and respect for diversity. The city has developed measures to support vulnerable groups such as immigrants, refugees and disabled individuals. Often referred to as the "city for people" due to its commitment to creating livable, sustainable and inclusive urban environment (Gehl, 2013). Copenhagen places a strong emphasis on inclusive design principles. The city strives to ensure that public spaces, buildings and transportation systems are accessible to all residents, regardless of their age, physical abilities or disabilities. Thus, inclusive design promotes equal participation and a sense of belonging for everyone within the urban environment. Furthermore, Copenhagen is known for its commitment to gender equality as policies and initiatives promote equal opportunities for women and men in employment, education and leadership roles.

Copenhagen faces challenges in terms of affordable housing due to the high demand of accommodation. The city has a well-developed social housing sector, providing subsidized rental apartments for families with limited incomes. The municipality promotes mixed-income residential development in which a percentage of units are designated as affordable housing, ensuring a diverse and inclusive urban environment (Alves, 2022)As the demand for affordable housing remains high, the city continues to explore innovative solutions such as repurposing underutilized buildings (Urban Rigger, 2023) and promoting sustainable and energy-efficient housing.

Another key feature of Copenhagen's smart people dimension is the residents' commitment to sustainability and environmental awareness. As the people actively participate in eco-friendly practices, such as cycling, using public transportation and reducing energy consumption, they embrace green lifestyle and are supportive of smart and sustainable initiatives (Quélin & Smadja, 2021). Furthermore, Copenhagen citizens are actively engaged in public consultations and community forums, contributing to decision-making processes and ensuring that the city's development aligns with their needs and expectations. Thus, they also demonstrate a strong sense of social responsibility, supporting community projects that target equity and inclusivity. Overall, Danish citizens are tech-savvy and open to adopting new technologies. They embrace digital tools and platforms which enables them to use digital resources effectively and access information.

3.5. Smart Governance

Smart governance refers to the use of technology, data and innovative approaches to improve accessibility, efficiency, transparency and responsiveness of governance processes. Over the last decade, Copenhagen has developed a robust digital infrastructure that enables the collection and analysis of data, supporting the implementation of smart solutions and enabling real-time monitoring of city systems and services (Quélin & Smadja, 2021). The city utilizes data and evidence-based approaches to inform decision-making processes. Data is collected

from sensors, IoT devices and citizen feedback and used to gain insights into urban issues and to identify areas for improvement. Some of the initiatives developed by Copenhagen Municipality include road condition sensors, real-time visualization of traffic flow (CITS), maps indicating the location of parking spots or public restrooms. This approach contributes to the optimization of resource allocation and the development of tailored services that meet the needs of citizens.

Open data initiatives are a key priority for Copenhagen. Free and open access to datasets supports innovation and collaboration among researchers, entrepreneurs and citizens (City Data Exchange). It also promotes transparency of governance by enabling residents to access and analyze public information, fostering accountability and trust (Copenhagen Cleantech Cluster, 2017). Thus, citizen engagement is facilitated by digital platforms and participatory initiatives as the municipality requests feedback, ideas and input from residents to co-create solutions and shape urban life. These initiatives facilitate the sense of ownership and ensure that services and policies reflect the needs and aspirations of the community.

Copenhagen's smart governance practices aim to create a sustainable, inclusive and livable city by harnessing technology, data and citizen engagement. Through automation, digital platforms and e-government solutions, governments can streamline service delivery, reduce administrative burdens and provide more personalized and citizen-centric services. Smart governance also involves collaboration and partnerships with various stakeholders, including private sector organizations, academia, civil society and international organizations (LSE Cities, 2014). The Copenhagen Solutions Lab, founded in 2014, is one example of such practices, encouraging citizens to take part in testing out smart and sustainable solutions in areas across the city. These collaborations foster innovation, knowledge exchange and the co-creation of solutions to complex challenges. By leveraging the expertise and resources of different actors, governments can achieve better outcomes and address complex societal issues more effectively (Quélin & Smadja, 2021). Furthermore, smart governance promotes resilience and future-readiness in the face of rapid technological advancements. By integrating digital technologies, governments can adapt to emerging challenges, harness new opportunities, and build agile and responsive governance systems.

3.6. Smart Economy

Copenhagen has a thriving and innovative entrepreneurial scene that embraces the principles of smart economy. The city fosters a culture of innovation and entrepreneurship, supporting startups and providing resources, mentoring and networking opportunities through incubators, accelerators and innovation hubs (LSE Cities, 2014). Initiatives such as Copenhagen Fintech Lab, Copenhagen Science City and CPH Village encourage the development of businesses and innovative solutions. The Green Tech Challenge is an accelerator program that supports green startups and businesses focused on sustainability. Selected participants receive mentorship, access to investors and training in areas such as circular economy, clean energy and management. The Copenhagen Fintech Lab is a hub for financial technology startups and entrepreneurs, offering co-working spaces and access to a network of investors and industry experts. The Copenhagen Street lab tests innovative urban technologies in real-life settings to improve mobility, air quality and energy efficiency.

Copenhagen Startup City is a dedicated initiative aimed at supporting startups by bringing together entrepreneurs, investors and industry partners. Another successful example is Symbion, Denmark's largest incubator for startups and growth-oriented companies, which focuses on sectors such as IT, cleantech, life sciences and creative industries (Copenhagen Cleantech Cluster, 2017). Overall, Copenhagen has a thriving startup ecosystem with a wide range of innovative companies and some notable ventures have emerged from there. Too Good To Go is a startup that aims to reduce food waste by connecting restaurants, cafes and grocery

stores with consumers through a mobile app, offering people the possibility to purchase food at a discounted price, and is currently used across Europe. Trustpilot is an online review platform that allows consumers to provide feedback and reviews on businesses, and has become one of the largest platforms globally.

Copenhagen is actively developing and implementing smart city solutions to enhance urban life and sustainability. The city invests in high-speed internet connectivity, smart grids and digital platforms to support the digital transformation across industries (The City of Copenhagen, 2022). This infrastructure enables businesses to leverage technological solutions to enhance productivity and competitiveness. These efforts are supported by a strong knowledge-based economy, as the city's universities, research institutions and high skilled workforce contribute to the thriving ecosystem and promote innovative clusters and collaboration between stakeholders.

Conclusions

Copenhagen has successfully established itself as a smart city that embodies the principles of sustainability, innovation and citizen-centric governance. Through its progressive policies and initiatives, the city has made significant strides in creating a more livable, environmentally friendly and inclusive urban environment. Copenhagen's focus on sustainable development is demonstrated by its ambitious goals to become carbon neutral by 2025. The city managed to reduce its carbon footprint and improve the air quality by adopting renewable energy sources and investing in cycling infrastructure. The commitment to sustainability extends to intelligent infrastructure such as smart grids and lighting systems that help optimize resource efficiency and enhance the quality of life of residents.

Copenhagen's efforts towards sustainability are also supported through mobility, as the city has prioritized cycling as a means of transportation, investing in cycling infrastructure and promoting bike-sharing programs. The extensive network of cycling lanes, bike-friendly streets and dedicated parking facilities have made cycling a convenient and preferred mode of transport for many residents. This focus on active and green mobility not only reduces congestion and carbon emissions but also promotes a healthier and more livable city. Moreover, Copenhagen implemented various measures that address climate adaptation. The city has integrated climate resilience into its urban planning, utilizing green infrastructure to mitigate effects of heavy rain. Furthermore, Copenhagen places great importance on preserving and enhancing its green and public spaces. Initiatives such as green roofs, pocket parks or vertical gardens contribute to a healthier environment.

The municipality's smart city approach also relies on citizen engagement, actively involving residents in decision-making processes, promoting a sense of ownership and co-creation. Copenhagen empowers citizens to contribute to urban development practices, report issues and collaborate with the administration, through digital platforms and mobile apps. This inclusive approach ensures that the city's smart initiatives align with the needs and aspirations of its diverse population. Furthermore, Copenhagen's emphasis on education and innovation has propelled it to the forefront of the global smart city movement. The city's research and innovation centers foster collaboration between stakeholders, such as academia, businesses and startups, driving forward advancements in various sectors. This approach on knowledge-driven growth ensures that Copenhagen remains at the cutting edge of technology and fosters a fruitful environment for entrepreneurship and economic development.

Overall, Copenhagen's sustainable smart city initiatives extend beyond energy and mobility to encompass circular economy practices, climate adaptation, green spaces, sustainable buildings and knowledge sharing. The city's comprehensive and integrated approach to sustainability sets an example for other cities seeking to become more resilient, livable and environmentally

friendly. By embracing innovation, engaging with citizens and facilitating collaboration, Copenhagen continues to lead the way in sustainable urban development.

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ADAPTING TO CHANGE: EMBRACING AGILITY IN SMART CITIES - FROM PROJECT MANAGEMENT TO ORGANIZATIONAL AND CITY PERSPECTIVES

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Abstract: Over the last few decades, the concept of agility has gained immense popularity in project management and organizations. Companies strive to enhance speed, foster adaptability to market dynamics, and promote innovation by implementing an agile strategy, adopting agile practices, and cultivating an agile mindset among leaders and employees. However, despite its widespread adoption, there remains ambiguity surrounding the precise meaning of agility and the critical factors for its successful implementation. In the context of transitioning towards smart cities, the active involvement of citizens is crucial. Their participation goes beyond making decisions and selecting projects; they play a vital role in the implementation process. The ever-evolving needs and desires of citizens require the implementation of agile practices and principles in projects developed within smart cities. The extensive acceptance of agile methodology in organizations engaged in software product development, coupled with their critical role in smart city development, facilitates the extension of agility from teams to entire organizations and cities. Scaling in both vertical and horizontal dimensions becomes imperative, along with an open attitude towards change and effective communication among community members and between them and local administrations. This paper aims to tackle the specific aspects related to the adoption of agile project management in organizations and smart cities.

Keywords: smart cities; agile project management; organization agility; citizen involvement

JEL classification: O22, M15, O3

Introduction

In recent years, the concept of agility has gained increasing popularity within organizations. Starting from the idea that people, the environment, organizations, and processes are in a perpetual state of change, an approach that would embrace and naturally encourage change has been seen as having significant chances of success. Organizational leaders are keen on accelerating their pace of innovation and adapting rapidly to economic and societal changes through the implementation of agile strategies. Simultaneously, there is a drive to cultivate an agile mindset among employees and managers at all levels, ensuring the necessary foundations for these transformations. Furthermore, Rigby, Sutherland, and Takeuchi (2016) argue that the concept of innovation itself has evolved with the widespread adoption of agility: not only new products and services are created, but innovation also resides within functional processes due to the swift spread of digital technologies. However, there remains a degree of ambiguity concerning the meaning of the agility concept and how it can be successfully implemented at

the community level. Their leaders have recognized the necessity of adopting agility in their processes and structures to align with the competitive, complex, and challenging business environment of the present. In a context where citizens, processes, organizations, and communities are in a perpetual state of change, an approach that accepts and inherently encourages change has been acknowledged as having significant potential for success.

Agile practices were initially used in software development projects to better respond to customer needs and improve quality and productivity. In this context, the plan-based approach was replaced by incremental and iterative development, and team self-management was enhanced. In recent years, agility has become a priority for service and goods providers, including infrastructure, as well as for beneficiaries of smart cities. It ensures adaptation to customer and citizen expectations and encourages change even in the advanced stages of project implementation. For community members, an agile way of life entails a continuous state of transformation, adaptation, and responsiveness to change. At the team level, agility involves self-organization, swift decision-making, transparency, collaboration, regular team reflection, customer-centricity, and an iterative approach to project development. A significant and favorable factor influencing team performance is proactivity.

Organizations and communities endeavor to improve their performance, to implement projects within a reasonable time frame that align with the planned budgets and that achieve or even exceed the expected outcomes. Doz and Kosonen (2010) consider strategic agility a crucial trait that enables organizations' leaders to plan and adapt their business models to become more responsive. Qalati et al. (2021) consider organizational, environmental, and technological factors as essential for performance. Environments characterized by a high level of uncertainty and change stimulate adaptability and innovation (AlTaweel and Al-Hawary, 2021). These factors serve as significant predictors of performance at both the organizational and community levels.

The paper aims to address the specific aspects related to the adoption of agile project management in organizations and smart cities. The remaining sections of the article are structured as follows: Section 1 presents a literature review on agile methodologies. In Section 2 the particularities of agility in smart cities projects are described. Section 3 provides some examples of smart city projects developed applying agile methodologies. The final section presents the conclusions drawn from the research.

1. Literature Review

Agility refers to the fundamental traits developed within organizations and employed to adapt to dynamic business environments. These qualities empower organizations to align, perceive, and react to such environments. One of the most critical challenges for companies to remain profitable and competitive in the present business environment and, in this context, agility has various interpretations. Over time, research has primarily focused on workforce agility and organizational agility. Although it addresses various perspectives, most definitions of organizational agility highlight four major components of agile organizations. The first involves *agile organizations responding promptly to internal or external changes in the business environment.* The factor is *the ability to anticipate change and act proactively*. The third component included in numerous definitions is *continuous learning and skills development, experience, and knowledge*. This aspect is particularly emphasized given the necessity of constant updating and the need to adapt its existing capabilities to manage an ever-changing environment (Skorecka, 2016). Finally, the literature highlights that a network structure, a people-centered and purpose-driven culture, as well as iterative product development processes, are trademarks of agile organizations and defines an agile organization as "a dense network of empowered teams that operate with high standards of alignment, accountability, expertise, transparency, and collaboration" (Aghina, et al., 2018). The

definition can be particularly useful when analyzing practical examples regarding the conduct of activities within organizations at all levels, operational, tactical, and strategic.

Special attention has been given to strategic agility. This is related to some sets of activities performed by organizations to add value in unstable and unpredictable business environments (Chan, et al., 2019). According to Sampath and Krishnamoorthy (2017), strategic agility as a meta-capability is related to allocating suitable resources to enhance specific competencies across an organization's functions while maintaining agility to ensure a balance over time. Doz (2020) highlighted that strategic agility helps organizations avoid "rigidity traps" and excessive focus on external embedding, moving away from organizational recession and shifting towards greater operational flexibility. From a strategic perspective, agile organizations are responsive to market changes and emerging opportunities. They are capable of quickly reorganizing their resources to capitalize on those opportunities and succeed in creating collective commitment, thereby avoiding issues generated by internal conflicts.

Within the contemporary dynamic business environment, Doz and Kosonen (2010) consider strategic agility as an essential capability adopted by organizations to plan and adjust their business model to become more interactive. According to Simpson and Agomor (2021), there are three main capacities of strategic agility: strategic sensitivity, resource fluidity, and leadership unity. *Strategic sensitivity* plays the role of enhancing the capabilities to recognize the surrounding environment and anticipate its changes, whether it's about opportunities that can be exploited or threats that, through proper planning and forecasting activities, can be avoided (Bondzi-Simpson and Agomor, 2021). *Resource fluidity* refers to an organization's ability to transform, gain a variety of new resources and skills for customer value creation, and transition toward contemporary business models. *Collective commitment* is defined as the "ability of the top team to make bold and fast decisions, without being bogged down in win-lose politics at the top" (Doz and Kosonen, 2008). It represents the leadership's support for collaboration, policies, collective commitment, and the swift simulation of decision-making processes that are time-sensitive in an ever-changing environment. Shirey (2015) further emphasized that the importance of collective commitment lies in the focus on initiating successful communication channels between different administrative levels within organizations.

The agile approach serves as an "umbrella" term for a set of project management methodologies (Denning, 2016), such as Scrum, eXtreme Programming (XP), Kanban, Feature-Driven Development (FDD), Dynamic Systems Development Method (DSDM), Adaptive Software Development (ASD), Crystal, Lean Software Development (LSD), among others. These methodologies offer alternatives to traditional methods with better quality, faster and more satisfying outcomes (Ceschi, et al., 2005). While initially proposed for software development, agile methodologies are now applied in many other fields, such as research and education, organizational culture, marketing, human resources, the banking sector, distribution, government, and the pharmacological industry, among others.

Agile Software Development (ASD) was formally introduced within the software engineering community through the Agile Manifesto in 2001. It encompasses four core values and twelve principles (Beck, et al., 2001). The Manifesto consolidates principles and values aimed at improving the software development process, exerting a significant influence on coordinating development teams. The agile movement cultivates a culture that embraces change and centers on customer requirements, with its distinctive feature being the ability to respond swiftly to dynamic customer needs. Agile frameworks are centered around the interaction and communication among project team members, involving the client in the planning, implementation and monitoring of the project's progress. Traditional software engineering lacks the flexibility to cope with frequent changes requested within a project. On the other hand, agile software engineering attracts clients by facilitating change, involving stakeholders

and development teams, and focusing on incremental and gradual growth. Projects developed with agile practices involve regular software delivery, prioritizing specifications that bring the most value. Since it is iterative and flexible, agile processes emphasize the consistent and rapid delivery of functional components of the final product. Unlike other methods, the agile approach uses feedback as a control mechanism to increase customer satisfaction (Wafa, et al., 2022).

Agile software development methods constitute a collection of easily adoptable practices that have attracted the interest of numerous organizations. They can be viewed as a response to traditional models, which assume a "rationalized, engineering-based" approach (Nerur, Mahapatra and Mangalaraj, 2005), where problems are completely specifiable, and there are optimal and predictable solutions. From the perspective of "traditionalists", efficient and predictable development involves encoded processes, extensive planning, and rigorous reuse (Jokela and Abrahamsson, 2004). On the other hand, agile processes address the challenges of an unpredictable world by relying on "individuals and their creative abilities, rather than processes" (Jokela and Abrahamsson, 2004). The motivation behind adopting agile methodologies stems from the high rate of failure of projects developed using less flexible traditional models. According to a study published by the Boston Consulting Group (2020), around 70% of digital transformation projects from the USA did not achieve the desired outcomes. Another study reveals that, in the past four years, organizations in the USA spent 30 billion USD on unused software (International Association of Information Technology Asset Managers, 2015). A successful project fulfils three simultaneous conditions: it is completed on time, stays within the estimated budget, and effectively serves the purpose for which it was created.

2. Agility in the Management of Smart City Projects

Agile development methods encompass approaches such as Scrum, Extreme Programming, Feature Driven Design Model, and the Crystal Family. All these frameworks are rooted in the values and principles outlined in the Agile Manifesto (Inflectra, 2022). Through a fusion of attributes and practices from various frameworks, hybrid models have been devised. Additionally, by expanding either vertically or horizontally, scaled agile models such as Nexus, Scaled Agile Framework (SAFe), and Large-Scale Scrum (LeSS) have been developed. The latter was designed to meet the needs of organizations dealing with large-scale and highly complex projects that require a substantial allocation of resources. These models provide valuable and flexible solutions to address challenges in large projects, enabling organizations to achieve consistent and predictable results in an ever-changing environment.

By implementing the principles and values of agility within organizations' business strategies, a positive impact on their performance can be achieved. Agile methodologies offer a flexible and iterative approach to development that harmonizes seamlessly with the dynamic nature of business environments. By adopting agile practices, organizations can swiftly react to market shifts, customer needs, and emerging opportunities. The focus on delivering value allows organizations to rapidly validate hypotheses, collect users' feedback, and make necessary adjustments to their business strategies. Conversely, the business strategy provides the guiding framework and context for agile teams, ensuring that development efforts are aligned with the organization's overall objectives and priorities. When properly integrated, the relationship between agile project management and business strategy empowers organizations to achieve their strategic goals while maintaining a competitive advantage in an ever-evolving market.

Smart cities are characterized by the pervasive integration of information and communication technologies, a domain where agile methodologies are extensively used in project development. Consequently, they influence, directly or indirectly, the evolution of cities. The dynamics of smart cities make it impractical to develop projects using traditional, rigid

methods. In the context of rapid technological advancements, establishing stable long-term plans becomes inefficient and may restrict the exploitation of all potential opportunities. The agile approach, which encourages breaking projects down into small components and continuous adaptation, can be a much more viable solution. This approach addresses both technological changes and the ever-changing demands of citizens. It also allows for the assimilation of emerging technologies, such as artificial intelligence, the Internet of Things, block chain, and business analytics, which are considered critical for the progress of smart cities.

Development in short iterations encourages experimentation, offers the chance to correct errors within a reasonable timeframe, and permits adaptation based on feedback from beneficiaries. Agile practices should extend across all levels, encompassing citizens, teams, organizations, and cities (Figure 1). The absence of engagement or widespread resistance toward embracing the values and principles of agility at any of these levels can erect barriers or hinder the progression of the city's intelligence.

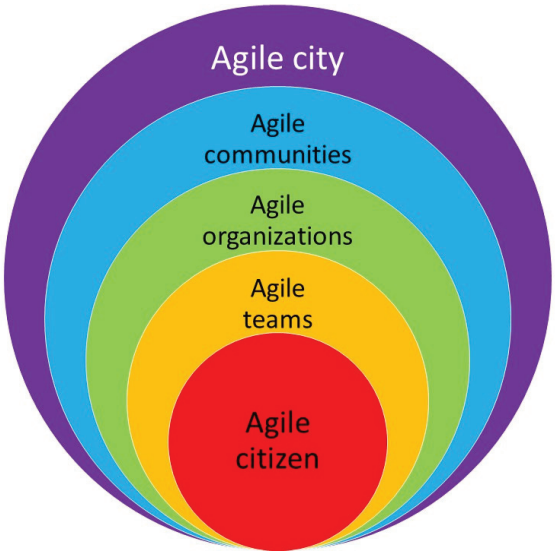

Figure 1: From agile citizen to agile cities

Source: author representation

Another advantage that agile practices offer to smart cities is a citizen-centric approach. Citizens stand as the primary beneficiaries of cities' heightened intelligence, making it imperative for initiatives from both public institutions and private organizations to prioritize enhancing their quality of life (Díaz and Ancán, 2020) within the context of sustainable economic, social, and environmental development. Smart cities must be responsive, stimulating citizen engagement in the development process and ensuring social equity through inclusion and justice (Chen, Ramon Gil-Garcia and Gasco-Hernandez, 2022). Non-agile approaches often prioritize top-down decision-making, limiting the consideration of citizens' perspectives and needs in the projects developed. Additionally, they lean on long-term planning, which can result in inefficient allocation of resources, particularly in cases where projects remain incomplete.

Another significant advantage of the agile approach in smart city projects is its ability to mitigate resistance to change. This is achieved by involving the beneficiaries of the product or service in the project development process, enabling them to test it at an early stage and request

adjustments based on their evolving needs. The following section provides examples of projects aimed at smart city development that have successfully incorporated specific practices from agile methodologies.

3. Illustrating Agile Project Management in Smart City Projects

Whether implicit or explicit, at a micro or global level, agile practices have played a role in the development of smart cities. This is particularly significant due to the prominent role of information and communication technologies in the development of which agile models are extensively used. This section offers a few examples of projects to underscore their substantial contribution.

An example of such a project is *Copenhagen Solutions Lab*, which endeavors to advance the city by testing and implementing intelligent and data-driven solutions, fostering an environment that supports citizens' needs and city growth (Copenhagen Solutions Lab, 2021). Through this project, an intelligent air quality monitoring system, a hybrid public transportation system, and energy-efficient street lighting solutions were implemented. The project team actively involved citizens who offered throughout the development process. The solutions were adapted based on their suggestions.

Singapore's Smart Nation Fellowship Program and the *Smart Nation Sensor Platform* provide citizens with the chance to actively contribute to the enhancement of their city's intelligence (Gattupalli, 2023). Through projects developed with agile methodologies, this city-state successfully introduced various facilities encompassing smart traffic management, innovative waste management, urban data analytics, smart water management, energy-efficient solutions, and digital government services. Like other smart cities, Singapore adopts a human-centered approach. Agile methodologies have streamlined the creation of a responsive and adaptive environment.

Superblock (Superilla) Barcelona project was conceived to mitigate traffic and improve air quality. It involved creating groups of several city blocks, interconnected through a network of streets closed to car traffic. Access and speed limits transformed the roads into open and safe public spaces for pedestrians to use for various purposes (Postaria, 2021). The project team used agile practices for iterative implementation. They started with a pilot project in 1993, developed two more superblocks in 2014, and an additional six since 2016. Throughout this duration, they monitored traffic and air quality in real-time and collected citizens' opinions. Based on this data, the project was continuously adapted to maximize its benefits. Stakeholders involved were residents, the city council, private companies, district organizations, non-governmental organizations, universities, and expert institutions (Postaria, 2021).

LinkNYC is a project implemented in New York in 2015 and is currently in its second generation, known as Link5G. Through this initiative, fast and free public Wi-Fi access was provided to New Yorkers, small businesses, and visitors. The program aimed to replace payphones with kiosks offering free calls, mobile device charging, and cost-free access to emergency numbers for taxpayers (Office of Technology & Innovation, 2023). The 5G technology led to the upgrade of services provided to ensure better service, easier access to free Wi-Fi, and improved options for home broadband internet access (NYC Department of Information Technology & Telecommunications, 2023).

The Smart City Amsterdam Project engaged the business environment, public administration, universities, research institutions, and citizens, collectively approaching the evolution towards a smart city (Gattupalli, 2023). The development was carried out using a bottom-up methodology centered around supporting startups, fostering social inclusion, promoting smart growth, and improving the overall quality of life for all citizens. Agile practices were integrated into various projects aimed at developing solutions for smart mobility, smart health, renewable

energy, and digital platforms for citizen engagement. Through the Smart Citizens Lab and the Smart City Community, citizens of Amsterdam are encouraged to participate in the development of the environment they desire to inhabit.

Conclusions

Considering the dynamic business landscape, marked by constant evolution, organizations and communities must seek ways to adapt to citizens' and market demands. Achieving these strategic objectives can be attained by addressing two critical factors, agility and strategy approached in a manner that facilitates continuous evolution. The relationship between these two factors is dynamic and symbiotic; they complement each other, stimulating innovation, enhancing flexibility, and contributing to strategic goal attainment.

A turning point in urban development is the paradigm change toward embracing agility in the context of smart cities. A change in how we think about, plan, and carry out urban transitions may be seen in the transition from traditional project management techniques to the comprehensive integration of agility across corporate and city-wide views.

In this paper, we have presented the specific aspects related to the adoption of agile project management in organizations and smart cities. Agile practices are gaining popularity among an increasing number of organizations from various public and private sectors. They serve as mechanisms to ensure return on investment and enhance the ability to cope with changes in a highly dynamic global market. In essence, agility involves minimizing the shortcomings associated with traditional methodologies to enable swift responses to environmental changes, user requirements, project deadline acceleration, and more. The ongoing innovation inherent to smart cities makes the specific approach of agile methodologies highly suitable for project implementation in these environments.

In conclusion, the shift from traditional project management techniques to an embrace of agility indicates a change that has the potential to reshape our urban environments. The incorporation of agility from project management to organizational and city views creates the conditions for smart cities to thrive as dynamic, sustainable, and people-centered hubs of the future by encouraging cooperation, innovation, and flexibility.

Acknowledgements: This work was supported by Jean Monnet Module "European Smart Cities for Sustainable Development"—SmartEU, co-funded by the European Union (620415-EPP-1-2020-1-RO-EPPJMO-MODULE) and the Faculty of Economics and Business Administration, Alexandru Ioan Cuza University of Iași, Romania.

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With the support of the
Erasmus+ Programme
of the European Union

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This volume is the result of the project Jean Monnet Module, „European Smart Cities for Sustainable Development" (SmartEU), reference no. 620415-EPP-1-2020-1-RO-EPPJMO-MODULE, supported by the Erasmus+ Programme of the European Union, and reunites a selection of the papers presented at the International Conference on „Sustainable Development of European Smart Cities" – SmartEU 2023, organized at the Faculty of Economics and Business Administration, Alexandru Ioan Cuza University of Iasi, in June 2023.

ISBN online: 978-606-714-781-0
(http://smarteu.uaic.ro/Pages/Start.aspx)
ISBN print: 978-606-714-806-0

EDITURA UNIVERSITĂŢII „ALEXANDRU IOAN CUZA" DIN IAŞI