Unlocking the Potential of German Smart Cities: Strategy Analysis through Online Content Examination

Matthias SCHMUCK,
Alexandru Ioan Cuza University of Iaşi, Iaşi, Romania
matthias.schmuck@student.uaic.ro, rsrch@bid-intelligence.com

Abstract
This paper presents a comprehensive analysis of smart city strategies in Germany through the examination of online content. Smart city initiatives have gained significant attention worldwide as urban areas seek innovative solutions to address various challenges. In Germany, renowned for its technological achievement and commitment to sustainability, has witnessed the emergence of numerous Smart City projects. The aim of this study is to investigate the current status of Smart Cities strategy initiatives in Germany based on a sample of 82 cities. To achieve this, an online content analysis methodology is employed, using the official web presences of the selected cities and information published on them. The content analysis focuses on identifying empirical evidence related to digitalisation, data and governance, and obtaining their transparency and progress in a sample of 82 major German cities. The findings of this study reveal the diversity and richness of German smart city approaches, but also a varying degree of sophistication and transparency of strategic initiatives. As an expression of Germany's federal structure, the cities focus on different aspects, such as mobility, energy efficiency or data-driven administration. The insights gained from this online content analysis provide valuable guidance for policymakers, urban planners and stakeholders involved in the design of smart city strategies. By understanding the strengths and weaknesses of existing initiatives, policymakers can refine their approaches, address challenges and promote sustainable and inclusive urban development. Furthermore, this study contributes to the academic discourse on smart cities by providing empirical evidence on the implementation of strategies in a German context. Overall, this study contributes to a deeper understanding of the German smart city landscape and serves as a basis for future research, policy formulation and the pursuit of smarter and more liveable cities.

Keywords: Digitalization, Data Strategy, Data Governance.

1. Introduction
The age of cities has entered with the new millennium, and the digitalisation of urban lifestyles is a global phenomenon. While the natural increase in population in earlier centuries was mainly in the countryside, today it is mainly in cities. Worldwide, more than half of the overall population already live in cities and this share will increase to two-thirds of the global population by 2050. [1] At the same time, cities take up the most resources.

The concentration of resources and people in a limited space causes social, ecological and structural challenges that also require a change in thinking and resources [2, 3], a result of population growth, bottlenecks in (affordable) housing and capacities of schools and day-care centres are occurring. High-income population groups are pushing lower-income groups out of the neighbourhoods. Furthermore, there is a risk of social segregation due to this trend, which impairs the stability of social conditions in the neighbourhoods.

Irreversible effects of climate change, including changes in the environment caused by heavy rain and strong winds, particularly affect cities. And as cities grow, political governance must continue to evolve, e.g. in addition to legal regulations through "soft policy instruments" such as more intensive cooperation with all policy levels [4, 5, 6, 7],

At the same time, this bundling offers great leverage and scaling potential for greater sustainability [8]

Emerging cities find orientation in the 17 global goals for sustainable development of the United Nations Agenda 2030 [9]. They include goals for greater crisis resilience, resource and energy efficiency, more sustainable consumption and mobility patterns, economic innovation and social inclusion. Accordingly, the goals also offer starting points for the challenges of increasing urbanisation. The term smart city has emerged, among other things, from the context of sustainable urban development. The term "smart" stands for the use of information technologies (IT) to optimise the use of resources and to manage cities more efficiently: our cities are being digitised [10]. The tools of sustainable and integrated urban development are being expanded to include technical components, so that society, people and their livelihoods will continue to be the focus in the future [11]. Digitalisation thus represents a comprehensive process of change in urban development as well; it changes the way we live, work, communicate, learn and manage our everyday lives. At the same time, however, there is also the risk of a "smart dictatorship" [12], because technological aspects are too much in the centre of attention, as a result of which the effects of urban digitalisation on social structures, basic democratic values, rights of disposal over data, etc. are pushed into the background.

Digital transformation of cities is not an end in itself [11, 13, 14], goals, strategies and structures are the tasks to be successful. The first step is therefore the strategy for digitalisation, which as a framework strategy must answer the question of how processes and models in the city can be digitally transformed and at the same time take into account the urban society with its different needs [11, 15, 16]. Cities should identify and define strategic fields of action for the smart city at an early stage and keep an eye on the effects of digitalisation, including the degree of networking of infrastructures and systems, data and services [11, 10], When dealing with the emerging data, it is important to develop data-specific goals and guidelines as well as ethics concepts in a data strategy in order to continue to ensure safe handling of the novel and sometimes sensitive data [17, 18, 19]. This data strategy is ultimately controlled via urban data governance [20, 21], which above all regulates different accesses to the data and thus enables new types of business and operator models. This requires secure, fast and simple digital identities.

This study examines the current status of strategy initiatives in smart cities in the Federal Republic of Germany (hereafter only Germany). Using an online content analysis, a coding scheme and a checklist, an attempt was made to obtain empirical evidence on strategy initiatives related to digitalisation, data and governance, as well as their transparency and progress in a sample of 82 major German cities (state capitals of the 16 federal states and cities with at least 100,000 inhabitants). Therefore, this paper focuses on the following three research questions (RQ):

(1) What is the current status of strategy efforts on digitalisation, data and governance in the selected sample?
(2) Which smart city action fields are addressed in each case?

(3) Which dimensions of data governance research are applicable to smart cities and how are they addressed in the sample?

The rest of this paper is structured as follows: Section 2 provides background information on the concept of smart city in general and in Germany in particular, on digitisation and strategy, on data and strategy and on data governance and strategy. Section 3 describes the research methodology applied and the material used. Section 4 presents and discusses the results of the online analysis. The paper concludes with a summary as well as remarks on originality, limitations and an outlook on further research directions in section 5.

2. Conceptual Background

This section introduces the relevant concepts. A framework (Figure 1) serves as a "structure guide" for the explanations in this section.

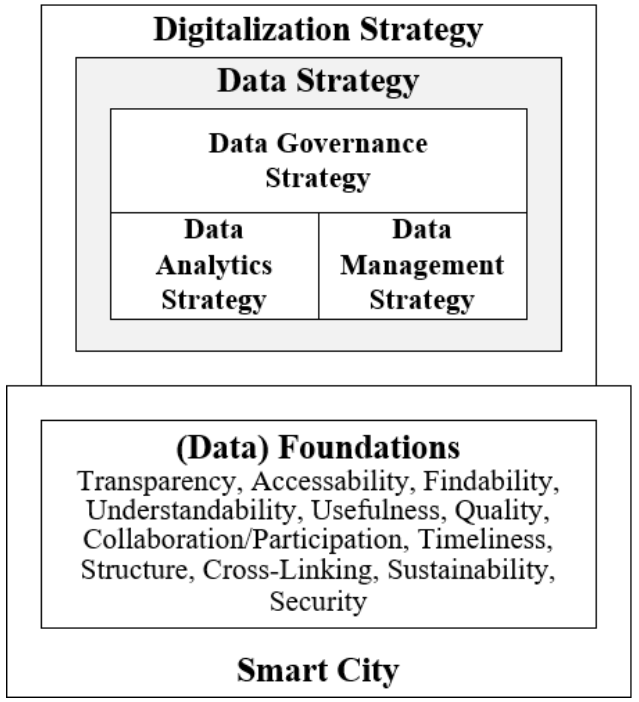

Figure 1: Framework
Source: Author's contribution

2.1 Smart City Concept

According to the results of the bibliometric analysis of [22], two dominant approaches are distinguished with regard to the extracted definitions for smart city: a technology-centred approach and a holistic approach. The technology-centred approach focuses on the penetration of urban space by information and communication technology (ICT) in the sense of network-like interconnected physical infrastructures [23]. Only a combined use of software, server and network infrastructure as well as client devices makes a city intelligent, which also results in the term urban critical infrastructure [10].The approach

has its origins in US companies such as IBM. In contrast, the holistic approach stems predominantly from the active exchange of knowledge between researchers at university institutions and attempts to find a balance of social, economic, cultural, environmental and technological aspects [24, 25]. In particular, the work of [26] focuses on people and defines six characteristic areas of a smart city: Economy, People, Governance, Mobility, Environment and Living [26] In this approach, ICTs are merely tools for solving urban problems.

The term smart city is not interpreted consistently globally [27, 28]. The view of the concept depends on whether a city is being created from scratch (so-called greenfield projects, e.g. Masdar City in the United Arab Emirates, New Songdo City in South Korea, Fujisawa in Japan) or whether existing cities are being digitised (so-called retrofitting of historically grown neighbourhoods). For this study, we agree with the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) that a smart city is the upgrading of cities and their infrastructures with digital technology and the linking of previously separate infrastructures or their subsystems [11]. These subsystems and infrastructures are, for example, energy, buildings, transport, water and wastewater. In the concept of the smart city, the "instruments of sustainable and integrated urban development are expanded to include technical components so that society, people and their livelihoods remain at the centre of attention in the future" [11]. In this context, cities are closed settlement areas with a high building density and population, a developed social structure and division of labour, which, due to its economic, political and cultural (also religious) significance, assumes a certain orientation function for the surrounding area [29].

There are a large number of related terms for the term smart city, which set certain emphasis in terms of content (Table 1).

Table 1. Diversity of terms for Smart City

Term	Content and delimitation	Reference(s)
Sustainable cities	Cities where successes in social, economic and physical development are maintained over the long term.	[30]
	Building on the three pillars of sustainability - environmental, social and economic sustainability - three basic dimensions are defined for urban sustainability: Economic efficiency in the use of development resources, social equity in the distribution of development successes and their costs, and the avoidance of developments that burden future generations.	[31]
Climate neutral cities	Cities whose emissions of greenhouse gases are reduced to such an extent that they can keep the global climate below the damaging threshold of global warming of 2 degrees, even if the world population rises steadily (to a predicted 9 billion in 2050). This therefore refers to all processes that do not emit any greenhouse gases or whose emissions can be fully compensated for and thus have no harmful effect on the climate.	[32, 33],
Green Cities	Influenced by Siemens' "Green City Index", the focus is on the ecological aspects of air purity, water quality, efficient traffic solutions, climate-friendly energy supply and intelligent building technology.	[34]

Term	Content and delimitation	Reference(s)
Greenfield Cities	These are concepts, especially in relation to start-ups of cities and municipalities, which essentially focus on smart cities as a technological concept based on the latest technologies.	[35]
Cities of the future (resource-efficient cities)	Cities that efficiently design the raw material and energy supply, processing, disposal and recycling of cities' resources to improve the quality of life and work, the benefit-cost ratio of city administrations and the competitiveness of cities.	[36]
Future City	Approach that pursues the holistic transformation of cities in pursuit of six strategic target systems: Climate Protection and Resource Efficiency, Adaptation to Climate Change, Economic Opportunities, Socially Sustainable Transformation, Urban and Stakeholder Innovation Capacity, Environmental and Quality of Life, and Strategic and Sustainable Use of New ICT Solutions. The transformation process is to be complemented by complementary and new fields of research and innovation in an implementation-oriented manner.	[37]
Intelligent Cities	While the smart city concept is often seen as a purely technology-oriented concept, this concept focuses on the drivers of climate change, resource availability and demographic change. In order to be able to react appropriately to these drivers, the concept of an "Intelligent City" contains at least the four fields of action of intelligent energy concepts, intelligent mobility, intelligent planning and administration, and intelligent economy. Together with the cross-cutting themes of information and communication technology, citizen participation and financing, these core areas form all clusters in which corresponding activities can be located.	[38]

Source: Author's contribution

Nevertheless, these terms also do not provide a conclusive definition, but do show a certain diversity of terms in the context of smart city.

The digital transformation of urban structures generates extensive amounts of data [39], which, according to the general view of practitioners and researchers, have an added value for the development of smart cities [40, 41, 42, 43], if they are processed in the interest of the general public of society. Here, the concept of "open data" - open, freely available and standardised data - has gained acceptance. The processing of urban data that is in the possession of public authorities has to follow basic concepts or framework conditions [44], the specifics of which are presented in Table 2.

Table 2. Basic concepts of urban data as public sector data

Concept	Urban data are ...	Reference(s)
Transparency	... transparent if they are generally public - an expression of the accountability of the public sector (this presupposes availability).	[45, 46],
Accessibility	... accessible if the public is given access to the data in a uniform manner (human- and machine-readable) and without any restriction; this presupposes transparency and voluntariness.	[45, 47, 19],

Concept	Urban data are ...	Reference(s)
Understandability	... understandable if there is a detailed description of the data in an easily understandable language and without abbreviations through the use of standards and metadata.	[48]
Usefulness	... useful if they are associated with a variety of different applications and can be used to answer urban development questions.	[49]
Quality	... of high quality if they are suitable for their intended use in operational business and decision-making ("fitness for use"). To this end, they must be accurate, available, complete, compliant, consistent, credible, processable, relevant and timely (so-called quality criteria).	[50, 51, 52],
Collaboration and participation	... transformative, if their use pursues the goal of learning together (collaboratively), optimising urban processes and thus changing real urban conditions constructively and sustainably. In essence, it is about identifying alternative scenarios, developing visions and dismantling inhibiting social hierarchies in order to search together for a sustainable future for their city.	[53]
Actuality	... are up-to-date if they correctly reflect the current state of the object or event and the extent to which the data are made available (in their latest version) without unnecessary delay.	[54, 55]
Structure	... of good structure if they are efficiently organised, i.e. stored, in accordance with the intended use and the goal of low storage requirements and high access speed (so-called functional efficiency).	[56, 57]
Cross-linking	... networked when they are made accessible via the Internet or other data networks in such a way that they are freed from their sectoral isolation and linked across previous domain and organisational boundaries, so that complex issues can be examined in the light of new facts and new connections can be revealed as a result, as well as new insights can be generated through their visualisation.	[19, 58, 59]
Sustainability	... (digitally) sustainable if they are collected, pre-sorted, categorised and stored on the basis of an underlying (data) strategy and with the sensible use of various information and communication technologies.	[60, 61]
Security	... are of an appropriate level of security on any infrastructure (including platforms), if security requirements and recommendations to ensure data protection and data security are provided for this purpose (compliance).	[62, 63]

Source: Author's contribution

2.2. Smart Cities in Germany

Germany is one of the six founding members of the European Union (EU) and the most populous country in the EU with around 83 million inhabitants [64]. The country achieved the fourth highest gross domestic product (GDP) in the world with around 4.1 trillion US dollars in 2022 [65] and the highest GDP within Europe and the EU [66]. Despite this formidable position of Germany in the EU and the world, Germany initially struggled with the digital transformation of its cities: Germany was and is not a "smart city pioneer" [27]. Germany's neighbours (e.g. Amsterdam in the Netherlands or Vienna in Austria) or other

EU member states (e.g. Barcelona in Spain) were much quicker to recognise the potential of smart cities. Nevertheless, the growing importance of the digital transformation with its technological possibilities as well as its power as an economic factor led responsible people in German city/municipal politics and administrations to deal with the concept of "Smart City" together with (national and international) technology companies as well as research institutions. Primarily driven by the large technology companies that develop solutions based on state-of-the-art ICT and offer them directly to municipalities and cities, however, "pioneer cities" such as Hamburg or Berlin can also be found as driving imitators.

In addition to this technological development, the political debate on the normative understanding of smart city and the concrete implementation (taking into account urban specifics) as well as the standardisation of smart city solutions (DIN/DKE 2015) are at the centre of urban changes in Germany. This has a tradition in Germany, and the special features of Germany as a federal state both inhibit and promote smart city development [67]. One result of these discussions is the "Smart City Charter of the Federal Government" [11], a catalogue consisting of guidelines and recommendations for action for the sustainable digital transformation of cities and municipalities. According to this, German smart cities are committed to sustainable and integrated stand development. The digital transformation is to be used for the sustainable development of resource-saving, demand-oriented solutions for central challenges of urban development. Strategy initiatives in the context of Smart City follow an extensive coordination and consultation process within the respective urban communities, usually in three phases: the identification phase, the participation phase and the condensation/decision phase [11].

The digital transformation process of German cities and municipalities is also being standardised at the regulatory level. In 2013, the German government passed the "Act to promote electronic government (E-Government Act, EgovG)" [68] and in 2017 the "Gesetz zur Verbesserung des Onlinezugangs zu Verwaltungsleistungen (Onlinezugangsgesetz, OZG)" [69]. This means that the digitisation of cities and municipalities in Germany is no longer a purely voluntary task. These laws are by no means to be considered separately from each other, but rather leverage mutual synergies. While the EgovG primarily sets the legal framework for the administration internally (such as the maintenance of an e-file or the establishment of an electronic payment procedure), the OZG primarily describes the framework externally, including which administrative services are to be provided digitally (e.g. via a portal network).

2.3. Digitalisation and Strategy

The term digitalisation has various meanings. On the one hand, it refers to the digital transformation of previously analogue processes, information and their interrelationships, and on the other hand to the process of change brought about by the introduction of digital technologies or the application systems based on them [70]. Digitalisation, also in the urban environment, needs a strategy [71].

Research distinguishes between a range of different strategies. For example, a distinction is made between "corporate strategies", so-called "business strategies", "IT strategies" and

"digital business strategies" [72, 73, 74]. A business strategy describes a classic business strategy that shows the direction of development for a given period by presenting the visions and goals of the organisation [73]. In comparison, an IT strategy is a written plan of projects that support a company's goals through the application of IT [75, 76]. If we now look at "digital business strategies", these are defined as corporate strategies that are intended to contribute to the organisation's value generation and competitiveness through the use of digital resources [77].

Regarding digitalisation strategies for cities and municipalities, [78, 79], provide a useful definition. According to this, a digitalisation strategy describes a holistic strategy that considers all areas of cities and municipalities, which uses the instrument of digitisation to promote the visions and goals of cities and municipalities and supports them in their development goals [78, 79] .

2.4. Data and Strategy

The result of increasing digitalisation is "digital footprints on global digital paths" represented by data as the digital equivalent of almost all (real) physical objects [80]. Thus, smart cities also have to consider why and for what purpose they want to use data. The focus is on all types of data that are important in the urban context, regardless of data origin, data management and any ownership and licensing relationships [81]. Due to their special characteristics (including versatility of format, volatility or replicability), data require special treatment [82, 83] .

A municipal data strategy defines the strategic orientation for handling data and creates uniform framework conditions within a municipality. It describes the data management in the municipality and the cooperation with external stakeholders in technological, organisational, ethical and legal terms. It addresses questions of which data may be made publicly accessible and which may not, which legal framework conditions must be taken into account and which (technical and organisational) infrastructures are needed to efficiently manage and store data and to share it with different actors as needed. It defines which data are required for which purposes in Smart City and shows the corresponding consequences in terms of resources, technologies and required know-how [84]. It helps define a vision with associated strategic principles (goals) against which each strategic decision is validated, as well as a set of clearly defined and easily measurable performance metrics to evaluate the impact of each activity or project [85].

In the context of Smart City, data strategies experience a normative framework: at the European level, this is the European Commission's Data Strategy, which "... aims to make the EU a frontrunner in a data-driven society. Creating a single market for data will allow it to flow freely within the EU and across sectors for the benefit of businesses, researchers and public administrations." [86]. Parts of this are the "European Data Governance Act" [87] and the "European Data Act" [88]. Examples of data-related strategy papers at national level are the Data Excellence Strategy of the City of Vienna [89], the Data Strategy of the German Federal Government [90], the Data Ethics Concept of the City of Ulm [91] and the Data Strategy Soest [92].

2.5. Data Governance and Strategy

The concept of data governance is inconsistent in literature [93]. Initially regarded as a further development of IT governance, this field of research became independent with the increasing importance of business intelligence and analytics, data management, data quality, big data, cloud computing as well as data protection and security. Today, in addition to purely technical-oriented definitions, e.g. [94], and purely management-oriented definitions, e.g. [95], we also find combinations of both camps for data governance, e.g. [96].

For this study, the MDM Institute provides a useful definition of DG as "... the formal orchestration of people, process, and technology to enable an organisation to leverage data as an enterprise asset." [97]. In general, it is about the definition of tasks, responsibilities, processes and guidelines for the handling and use of data and is oriented towards the strategic and operational goals of an organisation [98, 99, 100] . The goal of data governance is to improve and sustain data quality, which requires the support of all key decision-makers in an organisation [101]. Data governance encompasses decision domains, including data quality, data principles, metadata, data access and data lifecycle [102], data governance strategies encompasses their convergence [103]. Data governance is the tactical part of a data strategy; it supports the active design and enablement of a (smart city) organisation to make the best use of its data assets, as well as to manage the increasingly complex compliance requirements at low risk. As a guideline, data governance provides decision-makers with an orientation of the implementation to the intra-organisational area, i.e. to an existing organisation, as well as to the inter-organisational area, the relationship structure of the information-exchanging organisation [104, 105, 101] . Because data governance is a company-specific approach, individual implementations may vary.

Smart city data governance, also referred to as digital urban governance or just urban governance, stands for the form of governance (smart governance) that prevails in smart cities [106]. Due to the specificities of smart city, the general concept of data governance is therefore not transferable 1:1, but requires a transition (projection) to smart city development, redefining roles and responsibilities that have defined (and still define) traditional urban development [107].

The influence of smart city stakeholders on decision-making and participation processes relevant to urban development depends significantly on their data competencies and excellence, as well as on their access to data about city life. Urban data governance assumes a steering and guidance function here. The key to smart cities is data management, the ubiquitous data collection of urban services and processes. Because of this, increasingly digital city governments are concerned to provide an organisational framework for data management (capture, store, apply), i.e. to "define roles and responsibilities in decision-making processes that affect the data asset" [108] . Furthermore, state-of-the-art ICT is used to promote user-friendly communication between public institutions, policy makers and citizens, ensuring a high level of citizen empowerment and transparency in the design of public services [109].

Successful urban data governance thus aims to implement technical processes in technical systems that protect the interests of all stakeholders and society at large. To achieve this, a set of decision rules, criteria and indicators, processes, roles, responsibilities, and guidelines and standards are established. This requires coordination of all stakeholders at the technological, organisational as well as legal level.

3. Methodology and Material

From a scientific point of view, the methods section is an important part, as it contains all the information that enables other scientists to exactly repeat the experiments/studies based on the described materials and applied methods in order to check their reproducibility. Table 3 summarises the methodology and materials used in this study.

Table 3. Methodology and Material

Property	Description
Research approach	Qualitative
Research method	Content analysis via the internet (online content analysis)
Sample	82 cities in Germany (66 major cities, 16 state capitals)
Search Keyword/Term	"Strategy" OR "Digitisation" OR "Digitisation Strategy" OR "Smart City" OR "Smart City Strategy".
Time period	End May 2023

Source: Author's contribution

Research approach: Our study is based on an interpretative paradigm [110]. The focus of this study is on a qualitative study in which a content analysis was conducted in the context of official presences of the sample (82 German cities) on the internet (publicly available information). We agree with [111] that content analysis is an empirical method for the systematic, intersubjectively comprehensible description of content-related and formal characteristics of messages, usually with the aim of an interpretative inference based on this to facts external to the message. An important element of content analysis in general is the possibility of categorising different types of communication into measurable objects [112]. Important analysis categories in this context are above all text, image and sound [111].

Research method: Online content analysis (or web content analysis) is a sub-category of the general content analysis methodology. The focus is no longer on books or magazines, but on internet-based content. This virtual content has special characteristics compared to physical media: it changes over time in terms of appearance, structure and content. According to [113] a distinction is made between (a) classical content analysis, (b) structural analysis, (c) link analysis and (d) combined methods. While (a) focuses on the self-representation and argumentation strategies of the participants on the Internet presences, (b) aims exclusively at the formal structure of an Internet presence and (c) at the existing technical links between the different relevant pages of the Internet presence. In (d), the aforementioned methods are suitably linked with each other in an independent manner. The use of web content and documents contained therein as a data source is often referred to as a non-reactive measure. And data on official websites can be a better representation

of the phenomenon under investigation than data collected through self-reporting (e.g. in interviews or surveys) [114].

Sample: The sample for this study included 82 major cities and/or state capitals. The identification of this sample is based on the Smart City Index (SCI), the digital ranking for Germany's major cities [115]. Since 2019, all 81 German cities with a population of 100,000 or more - including 15 capitals of the 16 German federal states - have been examined annually in the five sectors Administration, Energy and Environment, IT and Communication, Mobility and Society/Urban Planning. With the help of these sectors, the questions of how digital the major German cities currently are, where the digital transformation is progressing rapidly and where it is sluggish, are being investigated. Within these five sectors, 36 indicators are formed and assigned to the five sectors. The 36 indicators in turn consist of 133 parameters, from online citizen services to sharing offers for mobility and intelligent traffic lights to broadband availability. In addition to the 81 large cities, Schwerin, the capital of Mecklenburg-Vorpommern and not included in the SCI because its population is less than 100,000, was included in the analysis. Each of the 82 cities' websites was searched for information on their digitalisation and smart city practices.

Search term and time period: The following search string was applied to the websites: "strategy" OR "digitalisation" OR "digitalisation strategy" OR "smart city" OR "smart city strategy". The search period was 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 digitisation (including strategy initiatives).

Evaluation: The first part of the evaluation process consisted of checking whether the cities in the sample have a digitalisation or smart city strategy and whether this is publicly accessible. This means that strategy documents/information were not explicitly requested (by phone or mail), but as an expression of transparency, it was expected that the cities, if available, make their strategy public by making it available for download on their websites. Publicly available strategy documents/information were then examined for information on smart city fields of action and the role of data, data strategy and data governance. The aim was to find out which fields the cities focus on in their concrete smart city measures and whether data is recognised as an asset by addressing a data/data governance strategy as part of the digitalisation/smart city strategy. Extending the topic of data governance, a checklist was further developed with criteria derived from the scientific literature and suitable for the smart city context [116, 117, 102, 118] . The criteria are presented in Table 4:

Table 4. Data Governance Criteria

Property	Description
Security	Statements on IT/information and data security, i.e. how the practical implementation of the protection of digital information against unauthorised access, damage or theft is carried out during the entire life cycle.
Privacy protection	Statements on the protection against the improper processing of personal or otherwise sensitive data as well as the protection of the right to informational self-determination

Property	Description
Data competence	Statements on the ability to critically collect, manage, evaluate and apply data, i.e. roles and responsibilities (including competencies, sovereignty)
Data ethics	Statements on the assessment of digital and data practices that have the potential to have a negative impact on people and society
Data Quality	Statements on the handling of data in terms of accuracy, completeness, validity, consistency, unambiguity, timeliness and usefulness.
Meta data	Statements on the structure and methodology of data documentation and maintenance
Data Stewardship	Statements on the formalisation of data management and responsibilities

Source: Author's contribution

Overlaps in the criteria were minimised in order to apply them to the online information of the sample.

4. Results/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.

4.1. Digital Strategy

The 82 German cities in the sample were examined to see whether a digitalisation strategy had been published or whether a concrete project was planned or had been started, or whether no information was available at all. Based on the available online information, the following results could be determined (Table 5):

Table 5. Digitalisation Strategy Results

Result	Description	Number	Share	Reference (Appendix)
No information available	No information available on the websites or in the documents.	29	35,4%	[2], [5], [8], [11], [12], [15], [18], [19], [23], [26], [27], [40], [44], [49], [52], [53], [54], [60], [63], [66], [69], [70], [72], [77], [78] [79]
Digitalisation strategy project planned	Concrete information that a project to develop a digitalisation strategy is planned.	5	6,1%	[36], [37], [45], [67], [71]
Ongoing digitalisation strategy project	Concrete information that a project to develop a digitalisation strategy has been launched.	4	4,9%	[25], [28], [59], [65]
Digitalisation strategy paper published	Digitalisation strategy paper is publicly available for download.	44	53,7%	[1], [3], [4], [6], [7], [9], [10], [13], [14], [16], [17], [20], [21], [22], [24], [29], [30], [31], [32], [33], [34],

Result	Description	Number	Share	Reference (Appendix)
				[35], [38], [39], [41], [43], [48], [50], [51], [55], [57], [56], [19], [61], [62], [64], [68], [74], [75], [76], [15], [79], [80], [81] [82]
	TOTAL	**82**	**100%**	

Source: Author's contribution

This evaluation brings up a painful subject: for more than a third of the sample (35.4%), no information on a digital strategy was publicly available. One explanation for the low percentage of published digital 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). Nevertheless, the results must be interpreted with caution, because the lack of public information does not automatically mean that there is no digital strategy or that work is not being done on the creation of a digital strategy. Other reasons for the lack of public information or for the lack of a digital strategy can be: lack of expertise (specialist knowledge), lack of demand from the population, lack of human and financial resources, low prioritisation compared to day-to-day business or unclear results. It should also be considered that smart city initiatives are often dependent on funding, which cities and municipalities have to apply for. Unexpected for the authors is that no city in the so-called five new federal states - Mecklenburg-Western Pomerania, Brandenburg, Saxony-Anhalt, Saxony and Thuringia (area of the former GDR) - are among the cities with a published digital strategy.

Germany as a federal state consists of 16 federal states. If the sample is analysed according to the capitals of these federal states, it can be seen that a digital strategy is publicly available on the web presences of 9 state capitals, but not for 7 state capitals (Table 6).

Table 6. Digital Strategy Publications by State Capitals

Part of Germany	State Capitel …	Number	Share	Reference (Appendix)
West Germany	... with published digitalisation strategy	9	11,0%[1] 20,5%[2] 56,2%[3]	[04], [10], [17], [29], [31], [41], [50], [55], [76]
	... without published digitalisation strategy	1	6,3%	[71]
East Germany	... with published digitalisation strategy	1	6,3%	[65]
	... without published digitalisation strategy	5	31,3%	[15] ,[18], [49], [73],[79]
	TOTAL	**16**	**100 %**	

Legend: [1] related to the entire sample of 82 cities | [2] related to all cities with a published digital strategy | [3] Related to all state capitals

Source: Author's contribution

This result was also not expected, as Germany is divided into several federal states by its federal constitutional system, which in turn have a state quality through their own (original)

state power. This means a fundamental authority to make decisions on matters, i.e. room for manoeuvre, which should come into play when it comes to the topic of "Smart City" - in terms of content as well as the time factor. In addition, there are many examples of digital strategies as references (e.g. Copenhagen, Vienna, Barcelona, Amsterdam) and instructions for action that only need to be adapted to the individual situation of the cities, which supports rapid implementation.

A more detailed analysis of the 44 cities with a digital strategy (Table 4) revealed, as expected, that the most populous German states - North Rhine-Westphalia (with 17 cities), Baden-Württemberg (with 9 cities), Lower Saxony (with 5 cities) and Bavaria (with 3 cities) - predominate (Table 7):

Table 7. Digitalisation strategy publications by federal states

Federal State	Cities with published digitalisation strategy (Reference, Appendix)	Number	Share	Federal state population @ 31.12.2022[1]
North Rhine-Westphalia	[01], [03], [06], [07], [14], [16], [17], [20], [24], [30], [34], [43], [53], [56], [68], [75], [81]	17	38,6%	18.139.116
Baden-Württemberg	[22], [32], [33], [39], [51], [61], [64], [76], [78]	9	20,5%	11.280.257
Lower Saxony	[09], [31], [35], [62], [80]	5	11,4%	8.140.242
Bavaria	[55], [58], [82]	3	6,8%	13.369.393
Hesse	[13], [21], [74]	3	6,8%	6.391.360
Rhineland-Palatinate	[38], [50]	2	4,5%	4.159.150
Schleswig Holstein	[41], [47]	2	4,5%	2.953.270
Bremen	[10]	1	2,3%	684.864
Berlin	[04]	1	2,3%	3.755.251
Hamburg	[29]	1	2,3%	1.892.122
	TOTAL	44	100%	

Legend: [1] Results of the population update based on the 2011 census, status: 20.06.2023 [119]

Source: Author's contribution

Bremen, Berlin and Hamburg are so-called city states, an entity that only encompasses the territory of a city (and, if applicable, its narrower surrounding area).

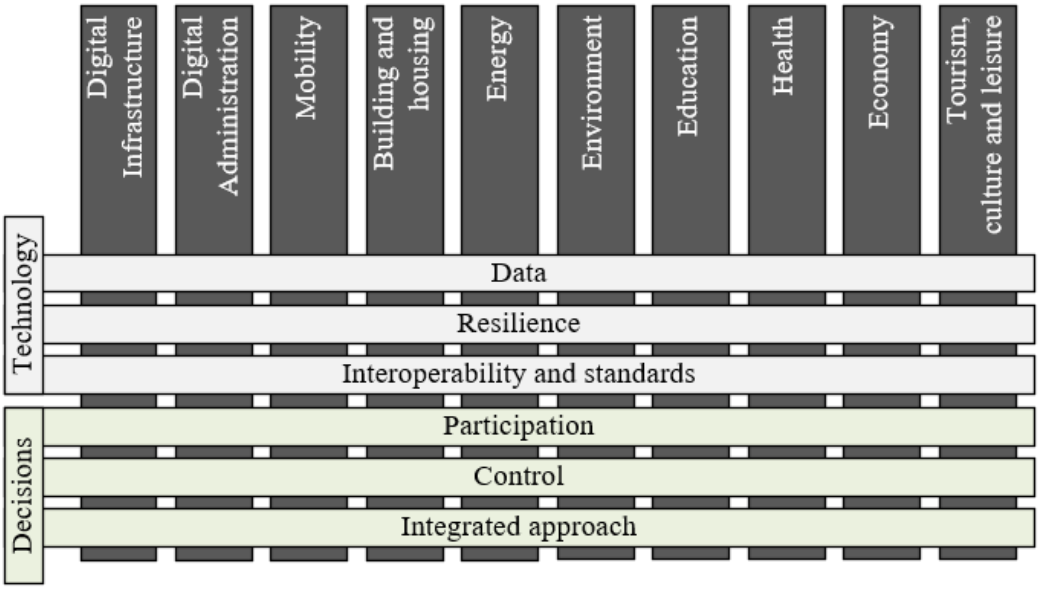

Fig 2. Fields of action Smart City by DIN SPEC 91387
Quelle: [120]

In order to integrate digitalisation into urban development and implement sustainable urban development goals, cities and municipalities should identify and define the strategic fields of action of the Smart City for themselves at an early stage [11]. The starting point for an analysis of the addressed Smart City fields of action in the sample is DIN SPEC 91387 "Municipalities and digital transformation - overview of fields of action" [120]. This defines 10 (vertical) fields of action: Digital Infrastructures, Digital Administration, Mobility, Construction and Housing, Energy, Environment, Education, Health, Economy and Tourism-Culture-Leisure. These 10 vertical fields of action are horizontally overlaid by the two main cross-cutting themes of technology and decisions, which in turn each consist of three thematic fields (Fig. 2). In this study, the 10 fields of action are expanded by a further category - management or overarching - in order to include characteristics of fields of action in the strategy documents that cannot be clearly assigned to one of the ten fields of action of DIN SPEC 91387.

Despite this standardisation, there are no standard definitions of fields of action in the analysed documents; Table 8 provides information on the diverse formulations:

Table 8. Smart City Fields of Action by DIN SPEC 91387:2020-08 and their characteristics in the strategy papers

#	Fields of Action	Characteristics in the strategy papers
1	Digital infrastructures	Citizen Services and Portals; Digital Infrastructure Development; Information & IT Security; Network Infrastructure; Data Infrastructure; Communication Infrastructure; Data Platform; Cybersecurity; IT Infrastructure; Data and Platforms; Broadband & 5G
2	Digital Administration	Administration; Digital Services; Digital Sessions; Digital Citizen Services; Digital Records Management; Enabling Administration; Digital Processes;

#	Fields of Action	Characteristics in the strategy papers
		Digital Work Processes and Services; Capacity Building and Organisational Development; Smart City Services; Smart Services; Policy and Administration; Digital City Administration; Digital & Citizen Administration; Legal Services; Smart Governance
3	Mobility	Mobility and transport; Sustainable and integrated mobility; Intelligent mobility; Smart mobility; Smart mobility and infrastructure; Smart and sustainable mobility; Mobility and transport; Environmentally friendly mobility; Networked mobility
4	Building and housing	Building & Housing; Inclusive Urban Design; Safe and Clean Urban Space; Disaster Prevention; Security and Trust; Space and Infrastructure; Living Together and Participating; Smart Living; Smart Housing and Neighbourhoods; Planning, Building and Living; Security; Smart House; Building, Housing, Living Space; Public Safety; Urban Development; Way of Life; Neighbourhood; Smart Home; Quality of Life
5	Energy	Energy and resource efficiency; decarbonisation
6	Environment	Climate and environment; Climate protection and climate impact adaptation; Environment and climate protection; Smart environment; Supply and disposal; Sustainable city; Green city
7	Education	Digitisation in schools; Digital education; Science and innovation transfer; Science and research transfer; Digital education and participation; Education and research; Trends, research and development; Smart education; Knowledge and education; Social participation; Education and coexistence; Education, innovation and research
8	Health	Health and Social Affairs; Smart Health; Worlds of Life, Family and Health; Health and Safety
9	Economy	New world of work and corporate culture; Resilient economy; Regenerative economy; Digital economy; Technology and start-up ecosystem; Economy and tourism; Work 4.0; Industry; Smart economy; Smart working; Economy, cooperation and innovation; Work and economy; Smart production; Innovative and sustainable business location; Climate-neutral economy; Common good economy
10	Tourism-Culture-Leisure	Sport and leisure; Digital access to culture; Urban experience; Society and culture; Trade and tourism; Culture, sport and leisure; Leisure and recreation; Smart culture
11	Management or overlapping	Public Safety; Citizen Participation; Future Opportunities for All; Participation and Networking; Society; Society, Ethics & Trust; Quality of Life and Participation; Care; Smart Crisis Management; Smart People; Inclusive, Inclusive and Participatory Society; Rescue and Disaster Response; Coexistence and Society

Source: Author's contribution

The wide range of formulations is an expression of the clash of different local starting points and requirements of the various actors (including citizens, business, science, administration, etc.) and thus a reflection of Germany's federal structure. This diversity is also visible in the number of defined fields of action in the strategy documents (Fig. 3).

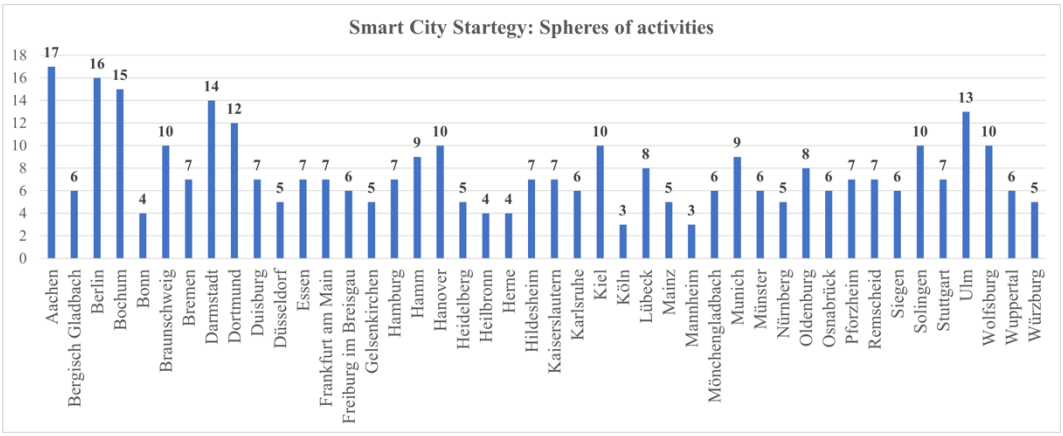

Fig. 3. Smart City fields of action and their number in the selected sample
Source: Author's contribution

The numbers vary from three (at Cologne and Mannheim) to 17 (at Aachen). Diversity increases complexity, dynamics and uncertainty, but also the comparability of results.

4.2. Data Strategy

The 44 German cities with a published digital strategy were further investigated as to whether a data strategy exists or whether a concrete project on this is planned or has been started or whether no information on this was available at all. Based on the available online information, the following results were determined (Table 9):

Table 9. Data Strategy Results

Result	Description	Number	Share	Reference (Appendix)
No information available	No information available on the websites or in the documents.	31	70,5%	[01], [03], [04], [09], [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" is named	The term "data strategy" is mentioned in the published information, but without further information on development and implementation.	4	9,1%	[07], [14], [39], [47]
Data strategy project planned	Concrete information that a project develop a data strategy is planned.	5	11,4%	[06], [61], [81], [82]
Ongoing data strategy project	Concrete information that a project develop a data strategy has been launched.	1	2,3%	[80]
Data strategy paper published	Data strategy paper is publicly available for download.	3	6,8%	[13], [32], [53], [78]
	TOTAL	44	100%	

Source: Author's contribution

From these results it can be deduced that only a few (four) cities in the sample have defined the strategic handling of data in a strategy, these are:

- In Mönchengladbach, model project Smart Cities since 2021, guidelines for a sovereign handling of urban data were developed in the context of the "Smart City Strategy Mönchengladbach", which, among other things, address questions of data ethics and the development of a data culture as a driver for innovation [121]
- For the City of Science Darmstadt, the city council adopted an open data strategy on 11 February 2021 [122], the aim of which is to create a basis for the systematic handling and provision of data of the City of Science Darmstadt, taking into account and not publishing personal data and data subject to confidentiality as a matter of course.
- The Rhine-Neckar metropolitan region, funded by the federal government as a model project of the 3rd season of "Smart Cities made in Germany" and of which Heidelberg is a municipal component, adopted a data strategy in mid-2022 as part of its smart city strategy with the aim of creating a municipal data space - from the neighbourhood to the region as well as supraregional actors [123].
- On 8 October 2020, the Ulm city council adopted a municipal data ethics concept, making the city of Ulm a pioneer in data ethics issues in Germany [90]. The concept complements the existing legal regulations on data protection. As a voluntary commitment by the city of Ulm and all municipal holdings, it defines guidelines and limits on how and for what purposes data may be used by the city of Ulm.

Nevertheless, the published information includes references to requirements, procedures and technologies for the collection and use of data, as well as governance and security structures that ensure responsible and ethically correct data use.

4.3. Data Governance Strategy

The 44 German cities with a published digital strategy were also examined to see whether a data governance strategy was available, whether a concrete project was planned, whether a concrete project had been started or whether no information was available. We also investigated which data governance fields of action are generally addressed. Based on the available online information, we determined the following results (Table 10):

Table 10. Data Governance Strategy Results

Result	Description	Number	Share	Reference (Appendix)
No information available	No information available on the websites or in the documents.	30	68,2%	[03], [09], [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" is named	The term "data governance strategy" is mentioned in the published information, but without further information on development and implementation.	7	15,9%	[01], [07], [29], [32], [47], [55], [79]

Result	Description	Number	Share	Reference (Appendix)
Data Governance strategy project planned	Concrete information that a project to develop a Data Governance strategy is planned.	5	11,4%	[06], [14], [50], [53], [81]
Ongoing Data Governance strategy project	Concrete information that a project to develop a Data Governance strategy has been launched.	1	2,3%	[04],
Data Governance strategy paper published	Data Governance strategy paper is publicly available for download.	1	2,3%	[78]
	TOTAL	**44**	**100%**	

Source: Author's contribution

This result was expected with regard to the evaluation results on data strategy (see Table 9). For about 68% of the cities surveyed, no information on the topic of data governance (not even the topic of governance itself) could be found on the online presences and documents. At least 12 cities are aware of the topic. Berlin has started the research project "Data & Smart City Governance using the example of air quality management" (duration until March 2025), which focuses on the development of a data governance concept based on the use case of a solution for air quality management for Berlin [124]. And a first data governance concept can be found for the city of Ulm [125]

Overall, however, the results show that there is a lack of a concrete road map for data governance in the cities studied, from which it is recognisable how a data strategy is to be brought into a lived framework. This is surprising, as many authors have demonstrated the added value of smart governance in practice - especially in the wake of the COVID 19 pandemic [106].

During the data collection, however, we noticed that in the accessible information - despite the lack of a concrete data governance strategy - fields of action of data governance were addressed. Based on this, we created a checklist (Table 4) to differentiate the information in this respect. In the following data analysis (Table 11), 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 11. Analysis of the Data Governance fields of action

Data Governance fields of action		Number	Share
Security	Statements on IT/information and data security, i.e. how the practical implementation of the protection of digital information against unauthorised access, damage or theft is carried out during the entire life cycle.	37	84,0 %
Privacy protection	Statements on the protection against the improper processing of personal or otherwise sensitive data as well as the protection of the right to informational self-determination	39	89,0 %

Data Governance fields of action		Number	Share
Data competence	Statements on the ability to critically collect, manage, evaluate and apply data, i.e. roles and responsibilities (including competencies, sovereignty)	26	59,0 %
Data ethics	Statements on the assessment of digital and data practices that have the potential to have a negative impact on people and society	14	32,0 %
Data Quality	Statements on the handling of data in terms of accuracy, completeness, validity, consistency, unambiguity, timeliness and usefulness.	14	32,0 %
Meta data	Statements on the structure and methodology of data documentation and maintenance	10	23,0 %
Data Stewardship	Statements on the formalisation of data management and responsibilities	20	45,0 %

Source: Author's contribution

The first analysis of the websites using the data governance checklist showed that a large majority of the German cities examined focus on the topics of data protection (89%) and data security (84%). From the author's point of view, this is also understandable, because cities are components of the public sector and are therefore subject to a special regulatory impact (including the GDPR). Modern information and communication technologies (ICT) are indispensable for an efficient and citizen-oriented city with its executive administrations. Many of these modern information technologies also entail data protection risks, so that the requirements for data protection-compliant administrative action must be continuously reviewed and adapted.

Slightly more than half (59%) are aware of the importance of data competence and excellence in the digital transformation to smart cities and define measures (including training, education). The focus is not only on data literacy, but also on digital and media literacy in general.

It is encouraging that a notable proportion of the cities surveyed (32%) have the courage to think beyond data protection and data security and address concrete ethical principles of behaviour. This behaviour is an expression of the fact that excessive caution, restraint and rigid adherence to laws and regulations alone do not seem to be the right thing to do. An ethically based code of conduct brings trust to all stakeholders in the digital transformation to smart cities and makes a first contribution to reconciling data-driven innovation with stakeholders' expectations of data protection and data security.

It also addresses the other key principles of data governance in the areas of data quality (32%), metadata documentation (23%) and data stewardship (45%), which is of fundamental importance if the agenda of smart cities is to make data openly available. Data accountability involves implementing procedures to determine data accuracy, reliability, integrity and security. Metadata documentation makes it easier for all stakeholders to find and use data and provide the critical data context that smart cities need. Bad data can have

significant consequences, and is often seen as the cause of operational breakdowns, inaccurate analysis and poorly thought-out business strategies.

5. Conclusion

In this chapter, the results are summarised and remarks are made on originality, limitations and an outlook on further research directions.

5.1 Summary

The digital transformation of municipalities and cities is the decisive building block for future development in Germany and the other member states of the European Union. It makes it possible to increase the quality of life, achieve locational advantages and master the societal challenges in a sociological, economic and ecological triad. Data and information are valuable assets for smart cities. This need requires a systematic governance of data and information and the goal should be strategic to take into account the needs and interests of all stakeholders - from residents, policymakers, administration to partners. This paper follows the exploratory approach and presents the results of an evidence-based research using online content analysis to demonstrate the current state of strategy initiatives in a sample of 82 German cities.

The results show that digital transformation has generally arrived in German (major) cities. The share of published digital strategy papers is 53.7 % (number = 44), which seems unexpectedly low. The reasons for this are manifold. In the opinion and experience of the author, one reason could be that strategies often only exist in the heads of municipal politicians and decision-makers, if strategic action is postulated for public bodies at all. It is also well known that Germany's federal structure - responsibilities are fragmented between the federal government, the states and the municipalities - is an obstacle to overcoming current problems, also in connection with the digital transformation, and therefore, there are always far-reaching recommendations for reform [126], [127], [128].

Furthermore, the value of data is recognised, but there is also a lack of strategic approaches. Only three of the 44 cities with a publicly available digitisation strategy have a data strategy, and only one has a data governance strategy. These values are also unexpectedly low and in this respect remarkable, because there is no lack of global examples of smart cities that German cities can learn from (e.g. Amsterdam, Helsinki, Singapore). The city of Ulm, as the only city with consistent strategic implementation, sets a good example in this respect by explicitly aligning itself with and being guided by such cities [125].

The specifics of public organisations compared to for-profit organisations - accountability, compliance and transparency - should be actively considered in the digital transformation. They are the basis of a public sphere that represents accessibility, equality and the management of public resources. The value of data as an essential outcome of digital transformation is recognised, but strategic approaches are largely lacking. However, given the huge amounts of data that smart cities will generate - now and in the future - a data strategy and data governance as a tactical part of the data strategy is needed to protect these data assets and to manage the data processes in this way. End-to-end strategic

implementation will be a critical factor for the success of smart cities in the forthcoming decades.

5.2. Originality

This study is the first to capture strategy initiatives around smart city, digitalisation and data in a sample of German cities. It thus contributes to the understanding of the current state of strategy initiatives in this research area in German cities.

5.3. Limitations

With regard to the analysis carried out, some limitations should be noted. The first limitation is that the sample refers to Germany. Germany is a federal state and unique in its state organisation, which is also reflected in the municipal structures and processes. Another limitation is the size of the sample with 82 cities. In principle, it would be necessary to conduct a total survey in order to be able to determine the characteristics of interest as precisely and accurately as possible for each individual member of the collective to be studied. In practice, it is not or hardly possible to implement this approach for reasons of cost and time. Nevertheless, the sample used here is representative.

5.4. Future research

It remains to be said that a consistent strategic implementation of the digital transformation process, data and governance will be a decisive factor for the success or failure of smart cities in the coming decades. Research should therefore continue to accompany this process.

However, the results presented here also suggest that further data collection, such as interviews or surveys, should be conducted in order to gain deeper insights into strategy initiatives in cities and into information that is not published on publicly accessible websites. The following questions can be addressed: (a) Evaluation of the strategy processes (What are the phases? Are citizens involved?); (b) Evaluation of the time periods from the start of the initiatives to their actual completion of a strategy process; (c) Evaluation of the organisations involved in the topic (Is there a C-level (e.g. Chief Digital Officer/CDO)? Is external advice sought?) or (d) Evaluation of collaborations in this area (benchmarking/orientation towards known "smart city lighthouses"?).

Acknowledgement(s)

Funding: This research received no external funding.

Conflicts of interest: The authors declare no conflicts of interest.

Appendix

Table 12. Sample set of German Smart Cities

[No]	City	Part of Germany	Federal State	State Capital?	Major City?
[01]	Aachen	West	Northrhine-Westphalia	No	Yes
[02]	Augsburg	West	Bavaria	No	Yes
[03]	Bergisch Gladbach	West	Northrhine-Westphalia	No	Yes
[04]	Berlin	West	Berlin	Yes	Yes

[No]	City	Part of Germany	Federal State	State Capital?	Major City?
[05]	Bielefeld	West	Lower Saxony	No	Yes
[06]	Bochum	West	Northrhine-Westphalia	No	Yes
[07]	Bonn	West	Northrhine-Westphalia	No	Yes
[08]	Bottrop	West	Northrhine-Westphalia	No	Yes
[09]	Braunschweig	West	Lower Saxony	No	Yes
[10]	Bremen	West	Bremen	Yes	Yes
[11]	Bremerhaven	West	Bremen	No	Yes
[12]	Chemnitz	Ost	Saxony	No	Yes
[13]	Darmstadt	West	Hesse	No	Yes
[14]	Dortmund	West	Northrhine-Westphalia	No	Yes
[15]	Dresden	Ost	Saxony	Yes	Yes
[16]	Duisburg	West	Northrhine-Westphalia	No	Yes
[17]	Düsseldorf	West	Northrhine-Westphalia	Yes	Yes
[18]	Erfurt	Ost	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)	Ost	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	Ost	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	Ost	Saxony	No	Yes
[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	Ost	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

[No]	City	Part of Germany	Federal State	State Capital?	Major City?
[65]	Potsdam	Ost	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	Ost	Mecklenburg Western Pomerania	No	Yes
[71]	Saarbrücken	West	Saarland	Yes	Yes
[72]	Salzgitter	West	Hesse	No	Yes
[73]	Schwerin	Ost	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: Author's contribution

References

[1] BMZ, "Hintergrund: Das Zeitalter der Städte," *Stadtentwicklung*, 31 july 2023.

[2] M. zur Nedden, "Digitalisierung als Element der integrierten Stadtentwicklung," 2017.

[3] S. Bauriedl, "Urbane Politische Ökologie," in *Handbuch Politische Ökologie, Theorien, Konflikte, Begriffe, Methoden*, 2022.

[4] Comparative Conclusions, "Comparative Conclusions - 'New' Environmental Policy Instruments: An Evolution or a Revolution in Environmental Policy?," *Environmental Politics, 12:1*, vol. 12, no. 1, pp. 201-224, 2003.

[5] R. Wurzel, A. Zito and A. Jordan, "From government towards governance? Exploring the role of soft policy instruments," *GPS*, vol. 9, pp. 21-48, 2013.

[6] J. Hertin, F. Berkhout, M. Wagner and D. Tyteca, "Are 'soft' policy instruments effective? The link between environmental management systems and the environmental performance of companies," *SPRU Working Paper Series 124*, Vols. SPRU - Science Policy Research Unit, University of Sussex Business School., 2004.

[7] S. Banerjee, M. Savani and G. Shreedhar, "Public support for 'soft' versus 'hard' public policies: Review of the evidence," *Journal of Behavioral Public Administration, 4(2)*, no. Vol. 4 No. 2, 2021.

[8] WBGU, "Unsere gemeinsame digitale Zukunft," *German Advisory Council on Global Change (WBGU) Hauptgutachten*, 2019.

[9] UN, "The 2030 Agenda for Sustainable Development of the United Nations," 2023.

[10] D. Washburn and U. Sindhu, "Helping CIOs Understand "Smart City" Initiatives Defining The Smart City, Its Drivers, And The Role Of The CIO, Forrester Research, Inc," 2010.

[11] BSSR, "Smart City Charta - Digitale Transformation in Kommunen nachhaltig gestalten," 2022.

[12] H. Welzer, Die smarte Diktatur, Frankfurt am Main: S. Fischer Verlag GmbH, 2016.

[13] Digital-Gipfel, "Handreichung zur Umsetzung der digitalen Transformation," 2017.

[14] Stadt.Land.Digital, "Lagebeschreibung Digitale Städte und Regionen. Digitale Lösungen für gesellschaftliche Herausforderungen," 2021.

[15] B. Niehaves, Röding. K, F. Oschinsky, H. C. Klein, A. Weigel and J. Hoffmann, "Digitalisierungsstrategien für Kommunen. Wissent," 2018.

[16] A. Strüver and T. Bork-Hüffer, "Stadt digitalisieren - Smartness jenseits des technologischen Optimierungsparadigmas," 2022.

[17] J. Sautter, "Urban Data Partnership," 2020.

[18] S. Pagliarin, D. Herrmann, D. Nicklas, H. Glückert, J. Meyer and P. Vizitiu, "Data Policies in Europäischen Smart Cities: Erfahrungen, Chance und Herausforderungen," 2021.

[19] J. von Lucke and K. Gollasch, "Offene Daten und offene Verwaltungsdaten - Öffnung von Datenbeständen," *Open Government, Edition eGov-Campus, Springer Gabler, Wiesbaden,*, 2022.

[20] J. Sautter, E. Dobrokhotova and W. Wendt, "Seminar Urban Data Governance," 2020.

[21] J. Franke and G. P. , "Data Governance and Regulation for Sustainable Smart Cities," *Frontiers in Sustainable Cities,* 2021.

[22] L. Mora, M. Deakin and R. Bolici, "The First Two Decades of Smart-City Research: A Bibliometric Analysis," *Journal of Urban Technology, 24:1,* pp. 3-27, 2017.

[23] J. Libbe, "Smart City: Herausforderung für die Stadtentwicklung," *Difu-Berichte 2/2014,* 2014.

[24] D. V. Gibson, G. Kozmetsky and R. Smilor, The Technopolis Phenomenon, Lanham, Md: Rowman & Littlefield, 1992.

[25] H. Lindskog, "Smart communities initiatives," 2004.

[26] R. Giffinger, C. Fertner, H. Kramar, R. Kalasek, N. Milanović and M. E. , "Smart cities. Ranking of European medium-sized cities," Cent. Reg. Sci. Vienna UT, 2007, pp. 1-12.

[27] R. Soike and J. Libbe, "Smart Cities in Deutschland – eine Bestandsaufnahme," *Difu Papers,* 2018.

[28] S. Kabisch, F. Koch and D. Rink, "Urbane Transformationen unter dem Leitbild der Nachhaltigkeit," *Geographische Rundschau,* pp. 4-9, 2018.

[29] K. Schubert and M. Klein, "Das Politiklexikon," *Bundeszentrale für politische Bildung,* 2020.

[30] UN-Habitat, "Planning Sustainable Cities UN-Habitat Practices and Perspectives," 2010.

[31] S. Argus, "Was ist eine nachhaltige Stadt?," 2010.

[32] B. Hirschl, "Klimaneutrale Stadte als zentrale Bausteine der Energiewende," *Ökologisches Wirtschaften,* 2015.

[33] EU-Parlament, "Was versteht man unter Klimaneutralität und wie kann diese bis 2050 erreicht werden?," 2023.

[34] Siemens, " A summary of the Green City Index research series," *The Green City Index* , 2012.

[35] M. Jaekel and K. Bronnert, Die digitale Evolution moderner Großstädte, Wiesbaden, 2013.

[36] BMVIT, "Bundesministerium für Verkehr, Innovation und Medien (Hrsg.)".

[37] BMBF, "Die Zukunftsstadt," 2015.

[38] B.A.U.M, "Intelligent Cities – Wege zu einer nachhaltigen, effizienten und lebenswerten Stadt," *Bundesdeutscher Arbeitskreis für Umweltbewusstes Management e. V,* 2013.

[39] F. Caputo, W. L. and Š. P. , "Towards a systems thinking based view for the governance of a smart city's ecosystem: A bridge to link Smart Technologies and Big Data," vol. 48 No. 1, pp. 108-123, 2019.

[40] F. Catal, N. Tcholtchev, P. Lämmel, S. I. Faruk Catal, B. Drescher, A. E. K. H. Thomas Fehling, Uli Hellweg and U. Jursch, Mensch und Technik in der Smart City, Smart City, 2018, pp. 143-158.

[41] M. Hörz, " Datenjournalistische Nutzung üblicher und unüblicher urbaner Daten," *Stadtforschung und Statistik,* pp. 35-42, 2016.

[42] A. Abella, M. Ortiz-de-Urbina-Criado and D.-P.-H. C. , "Information reuse in smart cities' ecosystems, Profesional De La información," *Cities,* no. 24(6), pp. 838-844, 2015.

[43] A. Abella, M. Ortiz-de-Urbina-Criado and D.-P.-H. C. , "A model for the analysis of data-driven innovation and value generation in smart cities' ecosystems," *Cities,* vol. 64, pp. 47-53, 2017.

[44] M. Lnenicka, A. Nikiforova, M. Luterek, A. O. D. Ukpabi, V. Valtenbergs and R. and Machová, "Transparency of open data ecosystems in smart cities: definition and assessment of the maturity of transparency in 22 smart cities," *Sustainable Cities and Society,* vol. 82, 2022.

[45] M. Janssen, R. Matheus, J. Longo and V. Weerakkody, "Transparency by-design as a foundation for open govemment,," pp. 2-8.

[46] M. Lnenicka and A. Nikiforova, "Transparency-by-design: What is the role of open data portals?," *Telematics and Informatics*, vol. 61.

[47] N. Veljkovic, S. Bogdanovic-Dinic and L. Stoimenov, "Offene Daten und offene Verwaltungsdaten – Öffnung von Datenbeständen," in *Open Government*, Wiesbaden, Edition eGov-Campus, Springer Gabler, 2014, pp. 278-290.

[48] I. Schieferdecker, "Urbane Datenräume und digitale Gemeingüter," *Instrumente für Open Government und mehr, In Praxishandbuch Forschungsdatenmanagement*, pp. 175-196, 2021.

[49] J. Kloiber, "Von offenen Daten zu nützlichen Anwendungen-Ein kollaborativer Prozess,," *ransparenz, Partizipation, Kollaboration - Die digitale Verwaltung neu danken*, pp. 203-210, 2014.

[50] A. Nikiforova, "Definition and Evaluation of Data Quality: User-Oriented Data Object-Driven Approach to Data Quality Assessment," *Baltic J. Modern Computing*, vol. 8, pp. 391-432, 2020.

[51] P. Oliveira, F. Rodrigues and P. Henriques, "A formal definition of data quality problems," 2005.

[52] D. M. Strong, Y. W. Lee and R. Y. Wang, "Data quality in context," *Communications of the ACM*, vol. 40(5), pp. 103-110, 1997.

[53] V. Weber and G. Ziemer, Die Digitale Stadt. Kuratierte Daten für urbane Kollaborationen, Bielefeld: transcript Verlag, 2023.

[54] B. Heinrich, M. Klier and Q. Görz, "Ein metrikbasierter Ansatz zur Messung der Aktualität von Daten in Informationssystemen," *Z Betriebswirtsch*, vol. 82, pp. 1193-1228, 2012.

[55] O. D. Support, "Die Qualität von offenen Daten & Metadaten, European Commission," *Trainingsmodul 2.2*, 2013.

[56] T. Ottmann and P. Widmayer, Algorithmen und Datenstrukturen, Heidelberg: Spektrum Akademischer Verlag, 2002.

[57] E. Horowitz, S. Sahni and S. Anderson-Freed, Grundlagen von Datenstrukturen in C, vol. 82, Bonn: International Thomson Publishing, 1994, pp. 1193-1228.

[58] J. von Lucke, C. Ochs, M. Friedewald, T. Hess and J. (. Lamla, "Spannende Gestaltungsperspektiven durch offene Verwaltungsdaten," in *Die Zukunft der Datenökonomie-Medienkulturen im digitalen Zeitalter*, Springer VS, 2019, pp. 343-365.

[59] J. von Lucke and C. Geiger, "Open Government Data," *Frei verfügbare Daten des offentlichen Sektors, Deutsche Telekom Institute for Connected Cities*, 2010.

[60] M. Dapp, "Open Government Data and Free Software – Cornerstones of a Digital Sustainability Agenda," *The 2013 Open Reader Stories and articles inspired by OKCon 2013: Open Data, Broad, Deep, Connected*, 2013.

[61] M. Stuermer, A.-T. G. and M. T. ., "Digital sustainability: basic conditions for sustainable digital artifacts and their ecosystems," *Sustain Sci*, vol. 12, pp. 247-262, 2017.

[62] A. Berger, G. Schwabe, N. Streitz and U. R. (. , "Sicherheit von Daten und Kommunikation," in *CSCW-Kompendium*, Springer, Berlin, Heidelberg, Springer Link, 2001, pp. 108-116.

[63] Y. Bozkurt, A. Rossmann and Z. Pervez, "A literature review of data governance and its applicability to smart cities," *Proceedings of the 55th Hawaii International Conference on System Sciences*, pp. 2680-2689, 2022.

[64] Europäische Commission, "Germany in the EU," 2023.

[65] Statista, "Ranking der 20 Länder mit dem größten Bruttoinlandsprodukt (BIP) im Jahr 2022," 2023.

[66] Statista, "Europäische Union: Bruttoinlandsprodukt (BIP) in den Mitgliedstaaten der EU im Jahr 2022," 2023.

[67] A. Schulte, "Warum die Digitalisierung der Behörden ein Flickenteppich ist," *Handelsblatt*, 2022.

[68] Federal Ministry of Justice (FMoJ), "Act to promote electronic government (E-Government Act - EgovG)," 2023.

[69] Federal Ministry of Justice (FMoJ), "Gesetz zur Verbesserung des Onlinezugangs zu Verwaltungsleistungen (Onlinezugangsgesetz - OZG)," 2023.

[70] K. Bengler, M. Z. Schmauder and .. A. Wiss, "Digitalisierung," vol. 70, pp. 75-76, 2016.

[71] A. Roth, "Digitalisierung: erfolgreiche digitale Transformation braucht eine Strategie," *Strategien erfolgreich entwickeln und umsetzen,* pp. 83-97, 2017.

[72] A. Bharadwaj, O. El Sawy, P. Pavlou and N. Venkatraman, "Digital business strategy: toward a next generation of insights," *MIS Quarterly 37,* pp. 471-482, 2013.

[73] D. Chen, M. M. D. Preston and A. Teubner, "Information Systems Strategy: Reconceptualization, Measurement, and Implications," *MIS Quarterly,* vol. 34, p. 233, 2010.

[74] S. Mithas, T. A. and W. Mitchell, "How a Firm's Competitive Environment and Digital Strategic Posture Influence Digital Business Strategy," *MIS Quarterly,* vol. 37, pp. 511-536, 2013.

[75] P. Gottschalk, "Strategic information systems planning: the IT strategy implementation matrix," *European Journal of Information Systems,* vol. 8, pp. 107-118, 1999.

[76] M. Atkins, "Information technology and information systems perspectives on business strategies," *The Journal of Strategic Information Systems,* vol. 3, pp. 123-135, 1994.

[77] Y. Chan and S. Huff, "Strategy: an information systems research perspective," *The Journal of Strategic Information Systems,* vol. 1, pp. 191-204, 1992.

[78] B. Niehaves, R. K, F. Oschinsky, K. H. A. Weigel and Hoffmann J., "Digitalisierungsstrategien für Kommunen," in *Studieim Rahmen des Frojekts "Digitale Modellkommunen",* Nordrhein-Westfalen, Siegen., 2018.

[79] B. Niehaves, R. K. and F. Oschinsky, "Structural Features of Digital Strategies for," The Art of Structuring- Bridging the Gap Between Information Systems Research an Practice, Springer International Fublishing. Cham, 2019, pp. 427-437.

[80] P. Gluchowski, "Vorwort,," *Gluchowski (Hrsg), Data Governance. Grundlagen, Konzepte und Anwendungen, 1. Auflage, dpunkt verag 2020,* 2020.

[81] Cuno S, Bruns L, Tcholtcher N and Lämmel P, "Data Governance and Information Governance: Set of Definitions in Relation to Data and Information as Part of DIKW," *Data Governance and Sovereignty,* 2019.

[82] J. Merkus, R. Helms and R. Kusters, "Data Governance and Information Governance: Set of Definitions in Relation to Data and Information as Part of DIKW," in *Proceedings of the 21st International Conference on Enterprise Information Systems,* vol. 10, SciTePress, 2019, pp. 143-154.

[83] J. Zygmuntowski, J., L. Zoboli and N. P. , "Embedding European values in data governance," *A case for public data commons Internet Policy Review,,* 2021.

[84] C. Koch and H. Beckmann, "H. Literaturrecherche über Vorgehensmodelle zur Entwicklung einer," *Wirtschaftsinformatik 2022 Froceedings,,* 2022.

[85] Liakh, O,, "Accountability through Sustainability Data Governance: Reconfiguring Reporting to Better Account for the Digital Acceleration, Sustainability,," p. 13814, 2021.

[86] EC, "European Data strategy. Making the EU a role mode for a society empowered by data," 2020.

[87] European Commission, "Data Governance A.," 2022.

[88] EC, "Data Act. Shaping Europe's digital future," 2023.

[89] Wien, "Data Excellence Strategie 2.0," 2023.

[90] Die Bundesregierung, "Datenstrategie der Bundesregierung," *Eine Innovationsstrategie für gesellschaftlichen Fortschritt und nachhaltiges Wachstum,* 2021.

[91] Ulm, "Datenstrategie Soest," *Datenethikkonzept der Stadt Ulm,* 2020.

[92] Soest, "Datenstrategie Soest,," pp. 05-14, 2021.

[93] M. Jagals, E. Karger and F. Ahlemann, "Already grown-up or still in puberty? A bibliometric review of 16 years of data governance research," in *Corporate Ownership & Control,* 2021, pp. 105-120.

[94] S. Lee and Zhu, "Designing data governance in platform ecosystems," 2018.

[95] K. Wende and B. Otto, "A Contingency Approach to Data Governance," *ICIQ-07,* 2007.

[96] Gregory, A, "Data governance - Protecting and unleashing the value of your customer data assets," *I Direct Data Digit Mark Pract,* vol. 12, pp. 230-248, 2011.

[97] MDM Institute, "What is Data Governance," *International journal of information management,* 2016.

[98] R. Abraham, J. Schneider and J. Vom Brocke, "Data governance: A conceptual framework structured review and research agenda," *International journal of information management,* vol. 49, pp. 424-438, 2019.

[99] K. C. Weber K, Data Governance-Referenzmodell. Organisatorische Gestaltung des unternehmensweiten Datenqualitätsmanagements, 2009.

[100] Weber K and K. C., Data Governance - Der Leitfaden für die Praxis, vol. 10, München.

[101] B. E. H. K. Al-Ruithe M., "Data governance taxonomy: cloud versus non-doud," *Sustainability,* vol. 10, no. 1, 2018.

[102] V. Khatri and C. Brown, "Designing Data Governance," *Communications of the ACM,* vol. 53, no. 1, pp. 148-152, 2010.

[103] A. Corradi, L. Foschini, A. Zanni, M. Casoni, M. 5. and F. Sprotetto, "A federation model to support semantic SPARQL queries for enterprise data governance," *ICDIM,* Vols. 96-100, 2016.

[104] M. K. E. Jagals, "NTER-ORGANIZATIONAL DATA GOVERNANCE: A LITERATURE REVIEW," *ECIS 2021 Research Papers,* vol. 57, 2021.

[105] D. Lis and O. B. , "Data Governance in Data Ecosystems - Insights from Organizations," *AMCIS 2020 Proceedings,* vol. 12, 2020.

[106] H. G. 5. W. P. Jiang, "Smart urban governance: an alternative to technocratic "smartness"," *Geo Journal,* pp. 1-17.

[107] S. Barns, "Smart cities and urban data platforms: Designing interfaces for smart governance," *City, Culture and Society,* vol. 12, pp. 5-12, 2017.

[108] L. Lupi, "City Data Plan: The Conceptualisation of a Policy Instrument for Data Governance in Smart Cities," *Urban Science,* vol. 3, no. 3.91, 2019.

[109] Z. Khan, A. Abbasi and P. Z. , "Blockchain and edge computing-based architecture for participatory smart city applications," *Concurrency and Computation: Practice and Experience,* vol. 12, p. 32, 2019.

[110] M. Alvesson and K. Sköldberg, "Reflexive methodology: New vistas for qualitative research," *Routledge,* vol. 12, 2010.

[111] W. Früh, "Inhaltsanalyse," *UVK-Verlag,* vol. 6, 2007.

[112] M. Welker, W. C. S. Böcking, A. Bock, A. Friedemann, M. Herbers, H. Isermannn, T. Knieper, M. S. S. Meier, P. C. and S. E. J. , "Die Online-Inhaltsanalyse: methodische Herausforderung, aber ohne Alterative," 2010.

[113] J. Schweitzer E, "Politische Websites als Gegenstand der Online-Inhaltsanalyse," 2010.

[114] B. M. Wildemuth, Application of social research methods to questions in information and library science, California: Libraries Unlimited, 2017.

[115] Bitkom, "Smart City Index 2022,," *Digitalranking,* 2022.

[116] Otto, "Data Governance," *Business & Information Systems Engineering,* vol. 3, no. 4, pp. 241-244, 2011.

[117] T. Koltay, "Data governance, data literacy and the management of data quality," *International Federation of Library Associations and Institutions,* vol. 42, no. 4, pp. 303-812, 2016.

[118] P. Brous, M. Janssen, and Vilminko-Heikkinen, R.H. J. Scholl, M. O. Glassey, B. Janssen, I. . Klievink, Lindgren and &. P. P.-c. e. al., "Coordinating decision-making in data management activities: A systematic review of data governance principles," pp. 115-125, 2016.

[119] dstatis, "Statistisches Bundesamt, Bevölkerung am 31.12.2022 nach Nationalität und Bundesländern," 2023.

[120] DIN SPEC 91387, "Communities and digital transformation - Overview of the spheres of activity," 2020.

[121] "Datenstrategie der Metropolregion Rhein-Neckar," 2022.

[122] "Open-Data-Strategie der Wissenschaftsstadt Darmstadt," 2021.

[123] "Datenstrategie der Metropolregion Rhein-Neckar," *2022*.

[124] Berlin, "Das Forschungsprojekt: Data & Smart City Governance am Beispiel von Luftgütemanagement," 2023.

[125] Ulm, "Smart City Strategie der Stadt Ulm," 2021.

[126] IW, "Föderalismus in Deutschland. Ökonomische Analyse und Reformbedarf," 2007.

[127] U. Jun, "Reformoptionen der politischen Akteure im deutschen Föderalismus: Mehr Länderautonomie und mehr Wett-bewerb als Ausweg aus der Politikverflechtungsfalle?," *Zeitschrift Für Parlamentsfragen*, vol. 35, no. 3, pp. 559-580, 2004.

[128] R. Sturm, "Föderalismusreform: Kein Erkenntnisproblem, warum aber ein Gestaltungs- und Entscheidungsproblem?," *Politische Vierteljahresschrift*, vol. 46, no. 2, pp. 195-203, 2005.