Towards data activation and engagement within a Smart City

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Abstract
As part of a doctoral study this paper provides a data use reference model for Smart Cities, based on the various interaction points in a city. The SCIEP conceptual model is a way to understand the variances and interdependencies between data users aiding in a city's transformation with new service delivery that is citizen centric. It advocates a move from technologically focused Smart City planning to a more complementary approach to different and changing urban contexts and communities. The SCIEP conceptual model model presented in this paper imagines Smart City implementation as being citizen- centric in its approach, involving participation by all city stakeholders in the establishment of co-created and data driven ecosystem known as the Smart City. It does this by considering Smart City implementation as the establishment of urban intelligence through widespread ICT deployment and exchange combined with co- production and collaborative practices towards the uncovering and establishment of "data-driven innovation" and value (i.e creating new products and services) within a digitally driven ecosystem. The data model presented adds to current academic debate by gaining a better understanding of the role that data, its producers and consumers play in supporting various stakeholder engagement and governance practices when developing Smart City services. It offers a model foregrounding collaborative engagement practices to ensure that smart initiatives and their deployment are well aligned and appropriate in relation to various participatory networks and community engagement practices to establish a more inclusive, active citizenry. It also offers a way to interpret Smart City implementation by considering the context in which it operates in order to unlock its value and potential for providing new services to citizens, to improve their quality of life and enhance social and economic transformation.

Author keywords
Smart Cities; Citizen Participation; Engagement; Governance; City Futures; Internet of Things; Technology

Introduction
This paper puts forward the SCIEP conceptual model. The SCIEP model offers a multi-dimensional approach, imagining Smart City implementation as an overarching strategy that takes into account the contextual interstices, people, domains and associated resources needed to mobilise public and stakeholder value. The Smart City concept emerged as a viable model towards improving urban management and public life through the application of ICT and the optimisation and integration of smart technologies (Madakam and Ramachandran, 2015:34). As an instrument, the Smart City aims at improving cities by mobilising all city stakeholders in the creation of sustainable and equitable cities rooted in the use of technologies to establish a co-created, intelligent and connected city (Chamoso, Gonzalez-Briones, Rodriguez and Corchado, 2018:2). In essence, the Smart City concept is an attempt to render cities more efficacious for their citizenry, utilising its ability to optimise and integrate all city functionalities and infrastructure, such as resource optimisation and the advancement of public services.However, as each city is unique, the unlocking of its Smart City potential requires an exploration of its context and variables towards understanding and improving its operational efficiencies and functionalities, such as improving urban systems and accelerating digital transformation for a broader citizenry (Caird and Hallett, 2019:189). This research looked at Smart City implementation as an engagement practice. It offers a model and reports on the components that advance data driven Smart City implementation and engagement and how these components may be developed as a broader Smart City vision.

Methods: Constructing the SCIEP conceptual model
As part of a doctoral study exploring Smart City implementation as an engagement practice for the city of Cape Town, South Africa, this research started with a systematic literature review (SLR) and content analysis. The review was based on the assumption that Smart City implementation can play a significant role in addressing current urbanisation issues; however, the associated mechanism for unlocking its potential is unclear. The objective of the first-phase content and document analysis was to identify the central Smart City discourse and associated constructs and approaches in literature. Results from this content analysis process revealed 63 key elements which pertain to the Smart City discourse and enable a broadly defined overview of the components that lead towards Smart City implementation and engagement. These constructs were further refined regarding their purpose, process and objectives related to the conceptualisation of data through a process of constant comparison, analysis and labelling of raw data as a way of inferring meaning. The accumulation of such inferred meaning provided "potential indicators of a phenomenon" and, through constant compar-

ison and analysis, identified the unit of analysis that informs the theory (Pandit, 1996:1).This systematic approach and analytical process of constant comparison of the data served to identify abstract representations of a phenomenon. It involved the clustering of concepts into categories as they pertain to a phenomenon. The outcomes of this process of constant comparison disclosed 17 constructs, explicitly related to understanding Smart City implementation as a co-created ecosystem. Moreover, the outcomes uncovered the components that lead to Smart City implementation, engagement and the advancement of a local, more inclusive environment. The 17 constructs were further developed and interpreted using an inductive approach of constant comparison in order to understand and develop a Smart City vision that is geared towards engagement. Seven main concepts, specific to Smart City implementation as an engagement process, emerged from this process: 1) data, 2) co-production, 3) citizen participation, 4) knowledge management, 5) Smart City initiatives, 6) Smart City maturity, and 7) Smart City domains. These were further developed into the Smart City Implementation as an Engagement Practice model (SCIEP).

Domains (Quadruple Helix)	Data (Lim, Kim and Maglio, 2018:94)	Co-Production (Castelnovo, 2015:4)	Citizen Participation (Simonofski et al., 2017:3)	Knowledge Management (Lichtenthaler and Lichtenthaler, 2009:1318)	Smart City Initiatives (Chourabi, Nam, Walker, Gil-Garcia, Mellouli, Nahon, Pardo and Scholl, 2012:2294)	Smart City Maturity IDC Smart City Maturity Model (SCM) (Alliance, 2014)	Smart City Domains (Cohen Boyd , 2012)
Inclusion	Local Network Development	Driven by Civil Society	Citizen as Democratic Participant	Knowledge exploration, Retention and Exploration	People and Community	Strategic Intent Data Use Technology Governance Stakeholder Engagement	People and Living
Infrastructure	Local Operational Management	Combination between Civil Servants and Citizens	Citizen as Users	Knowledge Exploration, Retention and Exploitation	Natural Environment and Infrastructure	Strategic Intent Data Use Technology Governance Stakeholder Engagement	Environment and Mobility
Governance	Preventative Local Administration	Combination between Civil Servants and Citizens	Citizens as Co-Creators	Knowledge exploration, Retention and Exploitation	Governance	Strategic Intent Data Use Technology Governance Stakeholder Engagement	Government
Economy	Local Information Diffusion	Driven by Citizens and Communities	Citizens as Co-Creators and Users	Knowledge exploration, Retention and Exploitation	Economy	Strategic Intent Data Use Technology Governance Stakeholder Engagement	Economy
Approach / Indicators (serves as interview protocol)	1. Managing Data 2. Integration 3. Privacy Issues 4. Delivery versus Need 5. Access	1. Experiment portal 2. Lessen Isolation 3. Annotation of Data 4. City Scale Opportunistic Data Collection 5. EaaS Framework		Knowledge Capacities 1. Inventive 2. Transformative 3. Innovative 4. Absorptive 5. Connective 6. Desorptive	1. Context 2. Co-Design 3. Deployment	1. Stage 1 2. Stage 2 3. Stage 3	1. Understands Smart City concept 2. Provides Evaluative Framework 3. Understands Relationality of Factors

Figure 1. SCIEP conceptual model (Author's construct, 2020)

SCIEP Axis and its Meaning

The SCIEP conceptual model imagines Smart City implementation as being citizen-centric in its approach, involving participation by all city stakeholders in the establishment of co created and data-driven ecosystem known as the Smart City. It does this by considering Smart City implementation as the establishment of urban intelligence through widespread ICT deployment and exchange, combined with co-production and collaborative practices towards the uncovering and establishment of "data-driven innovation" and value (i.e creating new products and services) within a digitally driven ecosystem (Abella et.al., 2017:51). As such, the SCIEP model provides a set of variables by which to activate or establish Smart City implementation which enables social and economic evolution, taking into account the contextual nuances of a city and its wider developmental objectives, such as bridging the digital divide (Boyle and Staines, 2019:26). As such, the SCIEP model also advocates Smart City implementation that facilitates the creation of a more inclusive citizenry and in which citizens are perceived as prosumers (both producers and consumers of content) within the digital urban environment, therefore calling for a bottom-up approach and more participatory governance models to solve urban challenges and understand required city and stakeholder needs (Gutierrez et al., 2016:4). The SCIEP model and its axis, which I discuss below, offer a multi-dimensional approach by which to imagine Smart City implementation as either an overarching strategy from which to work or as a stage-based implemented model towards initiating and driving Smart City initiatives or measure projects, taking into account the needed considerations as they pertain to the contextual interstices, people, domains and associated resources towards mobilising public and stakeholder value.

The vertical axis of the SCIEP conceptual model

The vertical axis of the SCIEP conceptual model serves as a stage-based model for Smart City implementation. It can be thought of as a means of initiating scalable and practical citizen centric solutions, that form part of a city's innovation strategy and ecosystem. For example, in the domain of citizen participation, implementation could have as its focus seeking to permit engagement of collaborative digital practices and environments with citizens and the city, by leveraging citizens as city partners of an urban innovation platform (Madakam and Ramaswamy, 2015:3). As captured in the domain, this could be achieved either through perceiving citizens as (1) democratic participants, (2) citizens as users, or (3) citizens as creators of services. This is important as successful Smart Cities and their service delivery require new ways of public and participant engagement within an urban setting, that allow for more inclusionary platforms to serve as catalysts towards empowering citizens and to transform city management services (Burt, 2001:298; Paskaleva et al., 2015:131). Similarly, as captured in the "data" component, the model highlights the potential usage of data as they relate to (1) developing a local community and how citizen generated data can be reused to help users, (2) local operational management and how data from service providers can be used to improve government and company processes through improved data interoperability, (3) preventive local administration and how data from various companies, users or service providers are captured and leveraged in order to better understand the urban context and problem areas, as well as increase operational efficiencies, and (4) local information diffusion and how data from service providers and customers are leveraged for their usefulness to wider citizenry or stakeholders (Lim et al., 2018:93). These components can also work in tandem in the sense that the overall focus could be on data-use and the development of local network whilst being responsive to how it relates to aspects, such as knowledge management and how knowledge is leveraged for innovation or transformation.

The horizontal axis of the SCIEP model

The horizontal axis of the SCIEP model, therefore, highlights all key Smart City components as they relate to understanding Smart City implementation as a citizen-centric practice that operates within and contends with complex urban environments bearing diverse heterogenous contexts and urban challenges. Its components (horizontal axis), therefore, serve as essential recommendations in perceiving or modelling Smart City implementation as a co-created ecosystem through an ongoing urban debate that utilises these components of data, co-production, citizen participation, knowledge management, Smart City initiatives, Smart City maturity and Smart City domains, in order to ensure that smart initiatives and their deployment are well aligned and appropriate in relation to various inclusive participatory networks and community engagement practices (Rodriguez-Bolivar, 2015). Furthermore, these key components and their activation as a framework for deployment ensure a better understanding and interpretation of what Smart City implementation should be in order to unlock its value with regard to providing new services to citizens, improving their quality of life and enhancing social and economic transformation and the advancement of a local more inclusive environment, while also focusing on adaptive, scalable and practical citizen-centric solutions as part of a city's innovation strategy and ecosystem (Gutierrez, Amaxilatis, Mylonas and Munoz, 2018:668). For example, the "Data" dimension calls for a data-driven Smart City approach where the activation of data is used as a tooling sport of Smart City initiatives. This dimension calls for consideration of issues, such as (1) associated challenges and required needs in dealing with a vast increase in generated data across distributed networks and data sources, (2) the structuring of data from several sources, such as sensors or city traffic cameras, etc., (3) the need for real-time data processing across city infrastructure and management, and user level, and (4) ensuring data reliability and value as gathered from several data sources (Santana et al., 2017:6). Furthermore, the "Data" domain considers the application of data analytics that support the application of IoT in matters, such as smart transportation, smart healthcare, the smart grid, etc. It also calls for a data-driven co-created city drawing on an array of distributed IoT technologies, data sources and data sets in order to resolve inner-city problems linked to better public services and an improvement in citizens' quality of life. This includes the leveraging of open data and the needed considerations with regard to making sure that (1) data are machine readable and facilitate use and reuse, (2) data are easily accessible on a publicly available online platform, (3) published data follow proper regulatory standards and formats in order to ensure interoperability between various data sets, (4) published data sets have an audit trail indicating the original, intended use which facilitates the interpretation of data sets and their use and reuse, (5) the need for a legal regulatory open data government framework that governs published data according to stakeholder concerns,(6) the need to define operational processes as a collective in order to regulate published data, as well as ensure data use, reuse and interoperability across data sets, (7) the need to generate and facilitate data interaction points between users in order to foster data supply and demand, as well as ensure data relevance and quality, (8) the need for a designated group of experts who manage a city's open data processes, and (9) the need to create and increase data demand in order to promote such issues as government transparency, efficiency improvement, and social and economic development (Nugroho et al., 2015:303).The components of co-production and citizen participation relate to garnering citizens participation in relation to planning and deployment of smart initiatives. As a set of recommendations, it centres around the need to establish collaborative citizen engagement and alternative forms of urban governance that allow citizenry and other stakeholders to collaboratively be part of the design and planning of urban spaces. This set of components supports a number of modalities of participation, as well as understanding the levels of participation within a Smart City, especially with regard to the context of the city and its people (Cardullo and Kitchin, 2019:5). Furthermore, citizen participation is seen as the means by which to enable public engagement, where digital communication tools are leveraged for their capacity to facilitate social conduct. As such, these tools often serve a mediating role towards activating aspects, such as co-production driven by citizens and communities, or citizen participation where citizens are co-creators and users of services (Niederer and Priester, 2016:137). Co-production and citizen participation, therefore, supports the application of digital tools to function as shared social objects towards identifying networks and their organisational conditions, as well as the "socio-material conditions" of communities or neighbourhoods (Niederer and Priester, 2016:137). Additionally, co-production and citizen participation reinforces sustainable forms of participation, and public and citizen engagement, centred around addressing public interests. Participation towards sustainability, therefore, includes the reconciliation of contextual nuances of place and space across the urban domains of economics, social factors and environment. It also supports participation, such as collaborative design, participatory decision-making, public discourse, participatory design challenges, policy integration and public resonance (Joss, 2014:49). The component "knowledge management" highlights the need to unlock latent urban value by supporting enhanced stakeholder interaction between industry, government, society and university. It, therefore, includes considerations around matters, such as open innovation and facilitating collaborative engagement amongst all participating city stakeholders towards a focused innovative action or goal (Paskaleva, et al., 2015:121). It includes a number of ways by which to leverage such engagement including inventive, absorptive and transformative capacities, etc. (Lichtenthaler and Lichtenthaler, 2009:1321). The "Smart City initiatives" component highlights key Smart City paradigms. These Smart City paradigms include (1) community and people, (2) natural environment and infrastructure, (3) governance, and (4) economy. It is within these paradigms, and with the establishment of these urban ecosystems in which social interaction occurs in diverse contexts, across different urban settings and with multiple associated social, infrastructural and technological characteristics, that smart services may be brought about through a blending of co-created social innovation practices based on actor or user needs (Aurigi and Odendaal, 2021:2). The "Smart City maturity" measures as part of the domain ways to determine a city's developmental stages in relation to its Smart City trajectory, as well as to ensure best practice and evaluation of Smart City projects. These measurements are (1) strategic intent, (2) data use, (3) technology, and (4) governance and stakeholder engagement. These variables can also be thought of as stage-based or sequential in nature, building on the preceding indictor or measurement in order to move towards full Smart City implementation. The component Smart City Domains highlights the key focus areas and factors towards establishing a Smart City that aims at resolving inner-city problems linked to public service availability, environmental sustainability, congestion, population density, inequality and liveability, infrastructure and management, and smart services. These domains relate to (1) technological implementation, hardware and software frameworks; (2) the use of technological solutions to improve people and communities, emphasising creativity, heterogeneity and education; and (3) institutional governance and policy assistance (Lee et al., 2014:82; Anttiroiko et al., 2014:325). The bottom row titled "Indicators" provides a set of variables or guidelines by which to test or measure the extent or successful implementation of initiatives according to their corresponding SCIEP components. For example, under the "Data" component five variables are highlighted by which to test data-driven Smart City deployment. These variables are used to measure aspects, such as how data are managed in relation to local network development, and to what degree they are accessed, integrated and delivered.

Significance and contribution of SCIEP conceptual Model

The SCIEP conceptual model is a framework by which to imagine or characterise what a Smart City and its initiatives can be when focused as an engagement practice involving all participating city stakeholders and users. It contributes to understanding Smart City implementation as a data-driven approach. Additionally, the establishment of urban intelligence, through widespread ICT deployment and exchange, serves as agency, combined with co-production and collaborative practices, towards the uncovering and establishment of "data-driven innovation" and value (i.e. creating new products and services) within a digitally driven ecosystem known as the Smart City (Abella et.al., 2017:51). The SCIEP conceptual model also takes into account the complexity and heterogeneous nature of modern urbanisation and the challenges many cities face in establishing relevant Smart City solutions. The model also offers the mechanisms and processes to be included in the creation of services, specifically in understanding how data - and access to data - within the Smart City concept add societal value through the synergy created by the exchange of data paired with citizen participation, a co-creation process and knowledge management approaches (Abella et.al., 2017:51). The SCIEP model adds to current academic debate by gaining a better understanding of the role that data, and producers and consumers of data, play in supporting various stakeholder engagements and governance practices when developing Smart City services. It offers a model which foregrounds collaborative engagement practices to ensure that smart initiatives and their deployment are well aligned and appropriate in relation to various participatory networks and community engagement practices to establish a more inclusive and active citizenry (Anttiroiko, 2015:26). It also offers a way to interpret Smart City implementation by considering the context in which it operates in order to unlock its value and potential for providing new services to citizens, to improve their quality of life and enhance social and economic transformation.

References

Madakam and Ramachandran. (2015). Barcelona Smart City: The Heaven on Earth (Internet of Things: Technological God). ZTE Communications, 13(4), 3–9.

Madakam and Ramaswamy. (2015), February. 100 New smart cities (India's smart vision). In 2015 5th National Symposium on Information Technology: Towards New Smart World (NSITNSW) (pp. 1-6). IEEE.

Madakam and Ramaswamy. (2015), February. 100 New smart cities (India's smart vision). In 2015 5th National Symposium on Information Technology: Towards New Smart World (NSITNSW) (pp. 1-6). IEEE.

Chamoso, Gonzalez Briones, Rodr´ıguez. (2018) Tendencies of technologies and platforms in smart cities: a state-of-the-art review', Wireless. Commun. Mob. Comput., 2018, pp. 1–17

Caird and Hallett. (2019). Towards evaluation design for smart city development. Journal of urban Design, 24(2), pp.188-209.

Pandit. (1996). The creation of theory: A recent application of the grounded theory method. The qualitative report, 2(4), pp.1-15.

Abella, Ortiz-de-Urbina-Criado and De-Pablos-Heredero. (2017). A model for the analysis of data-driven innovation and value generation in smart cities' ecosystems. Cities, 64, pp.47-53.

Boyle and Staines. (2019).Overviews and Analysis of Cape Town's Digital City Strategy. (URERU Smart City Series). Cape Town: Urban Real Estate Research Unit.

Guti´errez, Amaxilatis, Mylonas, Munoz. (2017). Empowering citizens toward the co-creation of sustainable cities. IEEE Internet of Things Journal, 5(2), pp.668-676.

Gutierrez, Theodoridis, Mylonas, Shi, Adeel, Diez, Amaxilatis, Choque, Camprodom, Mccann, Munoz, Zanella and Mahmoodi. (2016). Cocreating the cities of the future. Sensors, 16(11), p.1971.

Paskaleva, Cooper, Linde, Peterson and Gotz, (2015). Stakeholder engagement in the smart city: Making living labs work. In Transforming city governments for successful smart cities (pp. 115-145). Springer, Cham.

Burt. (2002). The social capital of structural holes. The new economic sociology: Developments in an emerging field, 148(90), p.122.

Lim, Kim and Maglio. (2018). Smart cities with big data: Reference models, challenges, and considerations. Cities, 82, 86–99.

Rodriguez-Bolivar. (2015). Transforming city governments for successful smart cities. Springer.

Santana, Chaves, Gerosa, Kon and Milojicic. (2017). Software platforms for smart cities: Concepts, requirements, challenges, and a unified reference architecture. ACM Computing Surveys (Csur), 50(6), pp.1- 37.

Nugroho, Zuiderwijk, Janssen and de Jong. (2015). A comparison of national open data policies: Lessons learned. Transforming Government: People, Process and Policy.

Cardullo and Kitchin. (2019). Being a 'citizen'in the smart city: Up and down the scaffold of smart citizen participation in Dublin, Ireland. GeoJournal, 84(1), pp.1-13.

Niederer and Priester. (2016). Smart citizens: Exploring the tools of the urban bottom-up movement. Computer Supported Cooperative Work (CSCW), 25(2), pp.137-152.

Joss, S. (2014). Rising to the challenge: public participation in sustainable urban development. in Hofmeister, Rueppel and Fook, eds, Eco-cities: Sharing European and Asian Best Practices and Experiences (Singapore: Select Books, 2014) 35–51.

Lichtenthaler and Lichtenthaler. (2009). A capability-based framework for open innovation: Complementing absorptive capacity. Journal of management studies, 46(8), pp.1315-1338.

Aurigi and Odendaal. (2022). From "Smart in the Box" to "Smart in the City": Rethinking the Socially Sustainable Smart City in Context. Sustainable Smart City Transitions, 53–68.

Anttiroiko. (2015). Smart cities: Building platforms for innovative local economic restructuring. In Transforming city governments for successful smart cities (pp. 23-41). Springer, Cham.

Lee and Lee. (2014). Developing and validating a citizen-centric typology for smart city services. Government Information Quarterly, 31, pp.S93-S105.

Lee, Hancock and Hu. (2014). Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. Technological Forecasting and Social Change, 89, 80–99.