UK smart cities present and future: An analysis of British smart cities through current and emerging technologies and practices [version 2; peer review: 3 approved]

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RESEARCH NOTE

REVISED UK smart cities present and future: An analysis of British smart cities through current and emerging technologies and practices [version 2; peer review: 3 approved]

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Abstract

This paper is premised upon an analysis of 26 cities within the UK regarding their smart city projects. Each city was analyzed through news articles, reports and policy documents to ascertain the level of each city's development as a smart city. Each was coded by separating the projects into five types, which were ranked on a scale from 0 (no plans for use) to 5 (project type in use). The most common types are the provision of open data and the creation of business ecosystems as the primary driver of the smart city. However, many councils and enterprises proclaim smartness before the technology is actually in use, making it difficult to separate what is utilised and what is under development. Therefore, this paper further carried out an analysis of 20 cities and their intended plans to usher in the smart city, to observe the expected emergence of smart city technology. This was achieved by interrogating various roadmaps and policy documents produced by the respective cities. It was found that the most prevalent form of emergent smart city technology is the rollout of 5G and increased educational programmes alongside a proliferation of internet of things and electric vehicle usage.

Keywords
Internet of Things, Public Policy, Smart City, Urban Areas, 5G

This article is included in the Sustainable Cities gateway.

Open Peer Review

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Introduction

The United Kingdom (UK) has enthusiastically embraced the smart city, with the majority of British cities seeking to integrate these technologies within their existing infrastructures. However, the actual extent of the embeddedness of smart solutions within UK cities remains unclear, particularly with regard to the scale of adoption, positive impact and plans for long-term investment. Overzealous local authorities and enterprises often effuse technological progress and urban development upon the back of announcing technical partnerships and preliminary testing; not necessarily on embedded or fully functional solutions. The ongoing need for private investment and government funding, which is perhaps reliant upon stories (not necessarily evidence) of success, is only one of the reasons for opaqueness in determining the extent of maturity of the smart city phenomenon. The authors do not further speculate on why this might be; however, this research seeks only to find objective data that reveals the landscape of the smart city in 2019 in the UK and its future trajectory towards 2030. This is done by analysing the level of actual progress made in 26 individual locations according to a five-point ranking scale. To accompany this, a policy analysis of 20 locations and their respective roadmaps, policies and strategies concerning the development of smart, digital and sustainable technologies and practices is provided in order to observe progress made and ascertain the future direction. Six of the cities researched were found to have, at the time of writing, insufficient plans and roadmaps set in place for analysis - Leicester, Norwich and the Scottish cities of Aberdeen, Edinburgh, Inverness, Perth and Stirling who are developing their smart city strategies in alignment with the Scottish Cities Alliance - which explains the shift in analysed cities and locations. It is also of importance to highlight here that the important debates and questions concerning the politics of smart city implementation and data accumulation also fall beyond the scope of this paper. This article pursues the relatively humble task of illustrating the current state of U.K smart city development and thus, seeks to answer the following research questions:

- What current technologies are prevalent in the British smart city?

- What practices are currently embedded within the smart city?

- In what direction is the smart city heading?

- What are the emerging technologies and practices most prevalent in the UK smart City?

This paper begins with an overview of the smart city concept, its aims and objectives, which provides a context for the main analysis. Next, the methodological section outlines the process and rationale of analysing each location, which is followed by an analysis of the levels of progress amongst many of the UK's smart cities, with a comparison of two very different approaches to being 'smart'. This leads into the analysis of the direction of British smart cities in the near future vis-a-vis the analysis of various roadmaps, strategies and policies, as well as the highlighting of specific examples of smart city technology and practice set to become established. The concluding section highlights five developments within the smart city which are most likely to become components of many cities within the UK.

This paper will be of interest to academics and practitioners who are seeking a holistic overview of the concept and status of smart city initiatives in the UK, including the emergence and ubiquitousness of enabling technologies, in the context of current practice and future strategies.

The Smart City

With the European Union supplying €301,929,322 to 17 'lighthouse' projects and 47 cities[1], with its industry being valued at US$1.56 Trillion[2] and with the Connected Places Catapult awarded £82,632,000 from the UK government[3]; the smart city is somewhat a financial juggernaut. With this level of investment, the smart city genie is very much out of the bottle. Yet what is a smart city?

The term 'smart' has become somewhat of a ubiquitous prefix to numerous technologies within our homes and environs. According to Emine Mine-Thompson "outside academia, the general 'smart' concept [has become] a generic term fused with data collection, sensors and various monitoring technologies, big data and internet of things (IoT)"[4]. Yet, to jump scales from the living room to the city, the smart city appears when the use of "ICT [makes] the critical infrastructure components and services of a city – which include city administration, education, healthcare, public safety, real estate, transportation, and utilities – more intelligent, interconnected, and efficient"[5]. Smart cities use the same technological entities and principles as the above examples – IoT, big data collection, connectivity, sensors and so on. However, unlike a smart TV or speaker, the smart city is context dependent. An example of this is how Singapore fights *Dengue* – a viral infection spread by mosquitoes[6]. One means of combating the disease is through local authorities alerting residents to Dengue clusters using the *OneService* app[7]. Another is the use of drones to investigate roof gutters which are "potential mosquito breeding habitats due mainly to a lack of maintenance. These are often located at a considerable height, making them difficult to be checked safely using traditional means [...] The drone is also equipped to dispense *Bti* larvicide and eradicate mosquito breeding habitat"[8].

Rob Kitchin, Professor of Human Geography at the National University of Ireland, has stated that "a smart city is one whose economy is increasingly driven by technically inspired innovation, creativity and entrepreneurship, enacted by smart people"[9].

This 'technically inspired innovation, creativity and entrepreneurship' is visible in the 'triple helix' structure of many smart cities. The "triple helix is the link between the universities, government and industry, and the innovation that is stimulated from this relationship"[10]. Many smart cities now work within a 'quadruple helix', which includes the three sectors above as well as participation from community groups and civil society, with some calling for a 'penta-helix' which identifies social entrepreneurs, bricoleurs, activists and assemblers as a distinct group of stakeholders[11,12].

This ushers in another element of the smart city, the desire to eradicate so-called silos. The 'silo effect' arises from "the immense tubular silos in which grain is stored. Workers in silos communicate poorly with each other"[13]. Silos within a city's organisational structure relate to different municipal departments working in parallel with each other, but not in unison. An example of a smart city project seeking to dismantle siloisation is observable in London with the city's *Datastore*. The city provides open data sets to the public concerning many topics, ranging from demographic and housing data to air quality data, yet according to the Smarter London Together roadmap "providing open data is only the beginning of the journey. The next step is combining that data in meaningful ways to better understand the way the city works"[14]. Through the holistic approach of combining data sets from diffuse departments, the Greater London Authority can grasp a better, granular understanding of the city.

In essence, the smart city is premised upon the sensing of the urban realm in order to extract data from it and apply said data to making the city more efficient and therefore more sustainable. Yet the smart city emerges in many forms, ranging from the harnessing of mobile phone data to using the latest in networking technology, from the tracking of public transport to the internet of things; the smart city is a diffuse and diverse entity and owing to the sheer diversity of different smart city technologies and practices, a set definition does not exist. This, therefore, raises several questions: What does the smart city look like? What form is it taking? What does 'smart' actually mean on the ground? Below is an outline of the methods used for this research to try and answer these questions.

Methods
Coding and analyzing the U.K Smart City
In order to understand and interpret the makeup of the smart city in the UK a coding schema is utilized. This research drew upon the 'four types' of smart city outlined by Tang *et al*.[15] – Essential Services, Smart Transportation, Broad Spectrum, Business Ecosystem – to analyze 26 UK cities and the smart city projects which currently operate within them. The cities assessed were Aberdeen, Belfast, Birmingham, Brighton, Bristol, Cambridge, Cardiff, Dundee, Edinburgh, Exeter, Glasgow, Inverness, Leeds, Liverpool, London, Manchester, Milton Keynes, Newcastle, Nottingham, Oxford, Perth, Peterborough, Reading, Sheffield, Sterling and York. In addition, the authors' have added another type to the schema – open data provider – which looks into the ease of access to city data sets. 'Essential services'

cities "are characterized by their use of mobile networks in their emergency management programs and by their digital healthcare services. These cities, that may already have good communications infrastructures, prefer to put their money into a few well-chosen smart city programs"[16]. For this paper the essential services model contained projects which were primarily concerned with updating and enabling the use of improved communication networks, including 5G network roll out, public wifi and the installation of long range low-power wide area network (LoRaWAN) networks, as well council operations - which were here deemed to be essential as they provide the digital backbone upon which the smart city exists; without these technologies and practices the smart city would not function.

Secondly, there is the 'smart transportation' type, "cities in this group emphasize initiatives to control urban congestion – through smart public transportation, car sharing and/or self-driving cars – as well as the use of information and communication technologies"[16]. Thirdly, the 'broad spectrum' type focuses on projects which "emphasize urban services, such as water, sewage and waste management, and seek technological solutions for pollution control. They are also characterized by a high level of civic participation"[16]. This research applied the broad spectrum label to projects which focused upon issues of sustainability and citizen engagement, ranging from retrofitting homes to the creation of living labs and hackathons. Finally, the *business ecosystem* type is applied to projects which intend "to use the potential of information and communication technologies to jumpstart economic activity"[16].

Table 1 contains examples of what constitutes each type of smart city project. Each city was analyzed and ranked on a scale of 0–5 for each type:

0. No measures underway or in the pipeline

1. Public announcement of plan or study

2. Study in advanced stages/detailed roadmap

3. Testing/trials of technology

4. Installation of technology on smaller scales

5. Fully established and integrated into the city

To ascertain each city's position within the smart city ranking schema, relevant documents, reports and news articles concerning each city were analyzed. These were located by initially using Google searches carried out during October–November 2019, through inputting <city name> plus "smart city" or "open data". From there more data and insight was accumulated via following the links provided by the aforementioned search engine. Findings were stored on Excel spreadsheets (see data availability) and coded (Table 1). Most of the cities researched report the progress of various initiatives and projects, therefore these projects were categorized according to type and were ranked using the scale. It must be noted, however, that this ranking is not intended to be used as a measure of a city's 'smartness' but rather a demonstration of how far down the road they are, for many cities are in the early stages of embracing smart city technology.

Table 1. Examples of smart city projects by type.

Smart city category	Examples of projects
Essential services	5G, 'gigabit' cities, full-fibre internet, free public wifi, LoRa (Low Power Long Range) networks, smart lampposts, bins and CCTV, operation centres, Internet of Things
Smart transportation	Digital ticket booking, smart cards, tracking apps, smart traffic solutions, investment into and testing of autonomous vehicles, mobility living lab (Dundee), EV (electric vehicle) charging points
Broad spectrum	Retrofitting buildings, digital social inclusion schemes, environment sensing, Hackathons, app challenges, living labs, citizen engagement events
Business ecosystem	Innovation Hubs, crowdfunding schemes, calls and project funding, close ties to academia, co-spaces and mobile working infrastructures, tech entrepreneurial networks
Open data provider	Council websites, Excel spreadsheets, platforms, urban dashboards, urban models, big data,

Results

Analysis of current smart city projects

The results of the analysis are available as *Underlying data*[17]. Overall, the most prevalent type of smart city infrastructure present in the UK is the provision of open data (Figure 1). In 2014, the Cabinet Office "identified the following priorities [...] get high quality open data out of government and into the public's hands; bring the power of open data to a wider audience and maintain Britain's global position as a leader on open data and transparency"[18]. The majority of UK cities have followed this desire and therefore have easily accessible data for the public to use with the best examples coming from Smart Cities Scotland, where seven cities (Aberdeen, Dundee, Edinburgh, Glasgow, Inverness, Perth and Sterling) utilise an open source data portal called the Comprehensive Knowledge Archive Network (CKAN). The benefit of having open data sets lies in the ability to utilize them and subsequently create smart city solutions as a result of that accessibility.

Business ecosystems. Asides from providing open data, many cities are currently investing in the delivery of the smart city vis-a-vis the fostering of a business ecosystem (Figure 2). A prevalent example of a business ecosystem is the innovation hub, the "[development of] creative places within the cities, such as in their historical centres or in old industrial or logistical areas" and as "'fusion places' where different uses coexist, such as business or entrepreneurial, research and development, education and learning, shopping and entertainment or community functions"[19]. Established innovation hubs can be found across the UK. Sensor City in Liverpool highlights the different uses and 'fusion' inherent with an innovation hub. It is home to 36 enterprises, ranging from manufacturers of sensors, consultancy firms, the Ministry of Defence (MOD) and software developers, runs regular events including conferences, 'surgeries' which cover aspects of running a business (Intellectual Property, Insurance and Risk, *Meet the Sensor Expert*) and is comprised of 22 suites, with co-working space also available[20].

Another means of supporting smart city startups and Small to Medium Enterprises (SMEs) is through the crowdfunding of

their development. For example, the *Crowdfund London* platform, provides an insight into the city. According to Theo Blackwell - the City of London's Chief Data Officer -

> "*The Crowdfund London platform allows anyone to propose and develop an idea for a neighbourhood project, then coordinate local support, resources and funding through a public campaign. The Mayor then pledges funds to live campaigns and supports local groups to make their ideas a reality. By understanding the needs of users across communities in London we've been able to lend additional support to areas where social capital needs that extra bit of help.*"[21]

Through the Crowdfund London, the mayor has financially supported 92 different projects to the tune of £3,630,484. In total the projects supported by the mayor have seen 11,569 separate instances of backing.

Broad spectrum. The broad spectrum grouping of projects concerns increasing sustainability across the city. A direct form of this is the retrofitment of existing buildings with more sustainable technologies. REMOUrban operates in Nottingham and is focused upon a goal to "improve energy efficiency for sustainable districts and the built environment" amongst other projects[22]. Nottingham has had 59 homes and 4 low-rise apartment blocks retrofitted in accordance with *Energiesprong* principles, an originally Dutch focus on home retrofitment which comprises of fitting a house "with new outside walls and windows, a solar roof, and a state of the art heating system, all in a matter of days"[23].

Another means of applying the broad-spectrum type can be observed in living labs. Cosgrave *et al.* state that "the premise of the Living Lab is that the city can be used as a real-world testing ground for new ideas and technologies"[10]. Located within the Edinburgh Futures Institute at Edinburgh University, *Edinburgh Living Lab* is the embodiment of the 'triple helix' - in their own words "our projects bring together industry, academia and public sectors to solve problems more holistically, promote
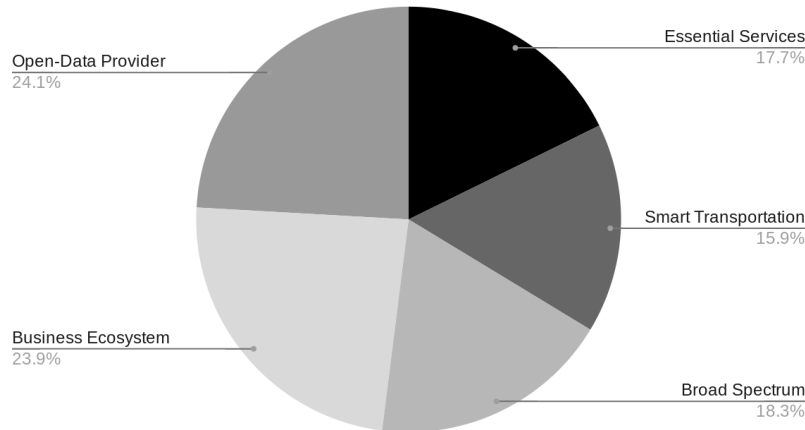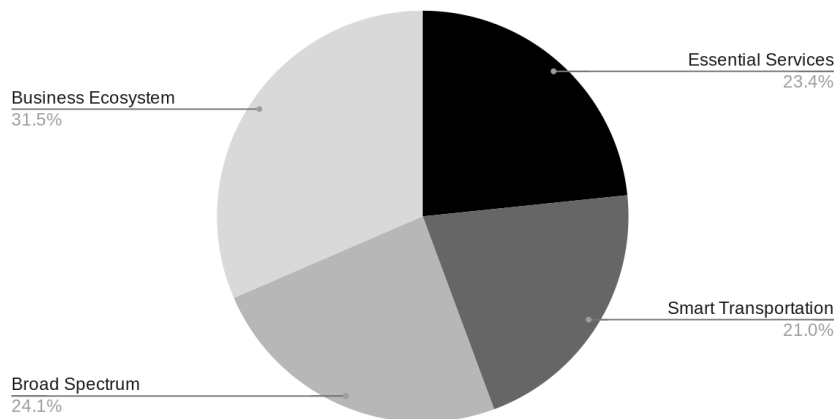
Chart 1: Prevalence of Current Smart City Types

Open-Data Provider
24.1%

Essential Services
17.7%

Smart Transportation
15.9%

Business Ecosystem
23.9%

Broad Spectrum
18.3%

Figure 1. Prevalence of current smart city types.

Chart 2: Prevalence of Current Smart City Types (Excl. Open Data Provider)

Business Ecosystem
31.5%

Essential Services
23.4%

Smart Transportation
21.0%

Broad Spectrum
24.1%

Figure 2. Prevalence of current smart city types, excluding "open data provider" which was omitted as it did not feature as a type in the analysis of smart city roadmaps (See: An Analysis of What's to Come).

resource and knowledge sharing, and build relationships"[24]. Amongst the lab's projects include "an ethical, privacy preserving system for capturing audio data about biodiversity in public parks", the "[development of] visualisations to make public data more accessible to current and potential users" and "through seven community workshops and extensive desk research, we mapped 703 cultural spaces reflecting the diversity of Edinburgh's creative and cultural activities"[24].

The living lab serves to offer an opportunity to test the latest smart technology in a real setting under the proviso of using the space as a laboratory, yet, there are numerous examples of cities using sensory technology already embedded in their infrastructural framework. Oxford is using a citizen led approach to sensing water levels in its surrounding rivers and streams via the *Flood Network,* a project reliant upon "low-cost wireless

sensors [which] harness the power of the Internet of Things to give you updates about waterways, rivers, ditches and even groundwater[25]. Another comes from Newcastle, with the Urban Observatory - based at the university - operating the *Sense My Street* project. Here residents can install sensors to obtain a better understanding of where they live:

> "*Get your local community involved in planning which sensors to use, and where to put them. A number of sensors, of various types and capabilities can be deployed around your part of the city. The sensors record the current conditions and transmit data wirelessly to our servers, which cleans, analyses and stores the data for you.*"[26]

During June 2019 Smart Belfast carried out five first phase projects in various public spaces, via the use of sensors and the

internet of things to understand footfall within them. The *Amazing Spaces, Smart Places* project offered £20,000 to five enterprises "to develop and trial an innovative [solutions] in one of our parks and open spaces"[27], with projects using numerous technologies, ranging from "anonymous wifi connection data to better understand the flow of people and footfall in Belfast City Cemetery", to "artificial intelligence and computer vision [determining] what is happening in a location"[27].

Essential services. These projects are concerned with the provision of networking technology. An example of this emerges in the form of Glasgow's Operations Centre.

> "*Glasgow Operations Centre is a state-of-the-art integrated traffic and public safety management system, created with the aid of the Innovate UK funding. The new centre brings together Public Space CCTV, security for the city council's museums and art galleries, Traffic Management and Police Intelligence.*"[28]

The city views the operations centre as a means of providing a platform for numerous infrastructures within the city. From one location, the city can be observed and controlled. A platform is a "digital infrastructure where two or more groups interact. They therefore position themselves as intermediaries that bring together different users"[29]. Platforms are an efficient means of overcoming siloization inherent within many city governments and can function as the nerve centre of a smart city network. Cambridge is a city which has embraced the platform as a vessel for the delivery of its version of the smart city with the *Intelligent City Platform*: "launched in March 2017, the Intelligent City Platform (iCP) is collating and processing real-time data from an array of sensors around the city that can be used in a host of applications"[30]. The iCP effuses data coming from a range of sources such as "traffic lights, bus movements, and car parks, together with new traffic monitoring cameras and air quality sensors [in order to] to monitor a range of measures including air quality, traffic, cycle and pedestrian movements"[30].

Each of these sensors, nodes and infrastructures are interconnected via a LoRaWAN connection. Johnston *et al*. state that LoRaWAN technology "promises long-range wireless communication to enable sensor deployments in remote areas or locations without connectivity"[31]. This utilization of a LoRaWAN benefits the city, for there is no need to install wide-ranging and fully comprehensive wifi coverage, which is expensive – the city of York estimated that a city-centre wide wifi network would cost £1 million to install[32] – or lay miles upon miles of network cabling, which is disruptive and time consuming, to ensure real-time sensor connectivity.

However, network connectivity not only concerns sensors and the internet of things, but also the citizens of each smart city. City Fibre are a leading enterprise in the installation of *full-fibre* internet and state that "the majority of broadband services marketed as 'fibre' today are only actually part fibre. They use fast fibre to the cabinet in your street, and then switch to slow copper cabling to your property"[33]. York is a beacon for the installation

of full-fibre internet, it has desires to be the "UK's first Ultra Fibre Optic city - the first city in the UK to have city-wide full-fibre all the way from the exchange into homes or businesses, making it a 'Gigabit city'"[34]. This is manifest in "one of Europe's best-preserved medieval streets", the *Shambles,* which now has internet speeds of 1000 Mbps[35].

Smart transportation. A form of smart transportation is manifested in travel cards with embedded microchips such as London's Oyster card. Brighton and Hove have their own equivalent of the oyster card where users "simply tap on at the start of each journey and tap off at the end of each journey using a contactless payment method"[36]. The 'smart' element within the tapping on and off lies within the ability to map the positioning of each journey with GPS, for every time a card is used to tap on, the card reader places where the passenger joined the bus and the same when it's time to depart and tap off. This technology is clearly demonstrated in Amsterdam.

To use Amsterdam's public transportation a passenger needs to use a ticket; either an OV-Chipkaart – the Dutch equivalent of an Oyster card – or a single use ticket which is made of card. However, within the ticket sits an embedded RFID microchip. In 2015, local artist Christian Nold removed the single use card's RFID chip and stuck it on euro notes and entered into an agreement with local businesses within the Bijlmer (Zuidoost Amsterdam), agreeing that if a customer would use one of these chipped notes they would receive a discount. These notes – the Bijlmer Euro – would be scanned at the shops and enter into local currency circulation. What the RFID chip enables is the 'traceability' of money, for "every shop participating in the project got an RFID reader, so the project could collect its usage data. [...] Traceability allows us to see from which shop to which shop the money has been moved directly by consumers and shows the pattern of connections of stores in the Bijlmer Euro network"[37]. Observing the movement of money around a local community demonstrates how transportation companies/ stakeholders can see the movement of people around a city's public transportation network.

This section serves to demonstrate current smart city technology and its uses within a demonstrative context. The next section briefly highlights two different city's approaches to the smart city by using the schema referred to above.

Two different smart cities

The two most advanced smart cities in the UK are London and Bristol, each scoring 25 (maximum) by demonstrating widespread use of each of the five different project types. However, it is of interest how smaller cities intend to introduce smart technology. Take Dundee, the Scottish city of 148,000 residents, which is proficient in two of the five areas: open data provision and smart transportation (Figure 3). Dundee uses the same CKAN open-source data portal platform as the other Scottish smart city projects, but it is also home to *The Mobility Innovation Living Lab* (Mill). Dundee "is now at the vanguard of the switch to zero-carbon transport"[38] with "20% of local taxis already entirely electric"[39]. The Mill is home to numerous smart
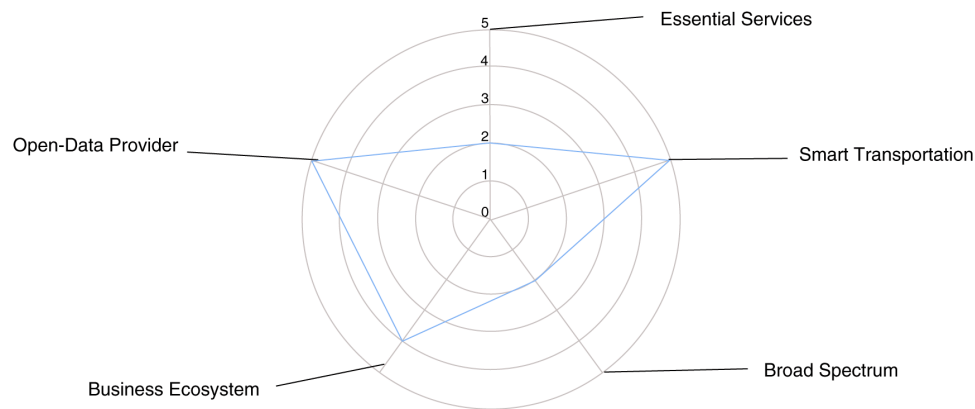
Figure 3. A radar graph showing the emphasis of Dundee's smart city development.

transportation solutions[40]. Dundee is focused on developing smart and sustainable mobility solutions, yet it scores comparatively poorly when essential services or the broad spectrum of smart city initiatives are concerned.

This the tacit opposite of Peterborough. The city of 175,000 is much more concerned with the broad spectrum of the smart city (Figure 4) and is set to become a 'gigabit' city in a similar vein as York. Peterborough's smart city drive is focused upon *Future Peterborough*, an initiative which has organised "projects [which] are citizen-centric, designed to support and empower the people living in our city"[41]. However, Peterborough's main drive lies in the circular economy. Herbert Girardet, ecologist and co-founder of the World Future Council, states that

> "*many cities today have a linear metabolism, nature's own ecosystems have an essentially circular metabolism [...] To become sustainable, cities have to develop [a] circular metabolism, using and re-using resources as efficiently as possible and minimising materials use and waste discharges into the natural environment*"[42].

For a city to embody the same circular model proposed by Girardet, much needs to be altered for it to be reached, yet Peterborough has started off down that path. To aid in the attainment of these approaches, the city has developed the *Share Peterborough* platform, "an online, resource sharing platform for businesses and other organizations in Peterborough."[43]. This serves as a vessel to bring diffuse actors together in order to minimize waste and make it "easy and convenient to find a new home for resources that you no longer need, and to find those resources that your business needs"[43]. What the examples of Dundee and Peterborough demonstrate is that they are both cities who are pursuing smart urbanism, but in their own way.

Analyzing the current state of smart city development in the UK is interesting and of importance, yet, in the words of Janet Abu-Lughod "cities are processes, not products"[44]. Cities are not static, closed entities, but develop and mutate, and there

is little else which develops and mutates more than emerging technology. Therefore, the next section is comprised of an analysis of various roadmaps, digital strategies and policy documents in order to ascertain which direction the smart city is developing towards and, ultimately, to make a speculative prediction of the embodiment the future smart city.

An analysis of what's to come

In order to analyze the not-too-distant smart city, this project reviewed 20 different locations and a total of 25 documents, which revealed 173 different initiatives. Each initiative was coded and grouped with the same four-types previously mentioned. As can be observed in Figure 1 and Figure 2 the prevalence of business ecosystem forms seen in the contemporary urbanism is the largest proportion of the smart city as a whole (30.6%). However, a dive into the various future projections on offer (Figure 5) demonstrates a move towards the provision of essential smart city infrastructure as the most prevalent (39.3%). It must be stated that these charts do not directly correlate because the data for the Figure 1 comes from the score given to the development of the grouping of technology, not the count of actual projects. A higher score in the Figure 1 relates to the delivery type of smart city and whether that project is existent in a certain location and not in a developmental stage; it is temporal in nature. Whereas in Figure 2 and the following sections of this paper, all of the projects are in a developmental stage as the analysis is speculative and based in the future.

However, saying this, there is merit in the comparison of these charts as they do impact one another. Firstly, the high percentage of business ecosystems in Figure 1 influences its prevalence in Figure 2, for if a city already has an infrastructure in place, it will not seek to build it again. Secondly the prevalence of essential services in Figure 2 demonstrates that the technology is close at hand and therefore soon to be implemented. Cambridge is an example of essential service technology being currently operated by a city – with its LoRaWAN – yet it was only one of a few which had essential service projects up and running (Bristol, London and York amongst others). The above
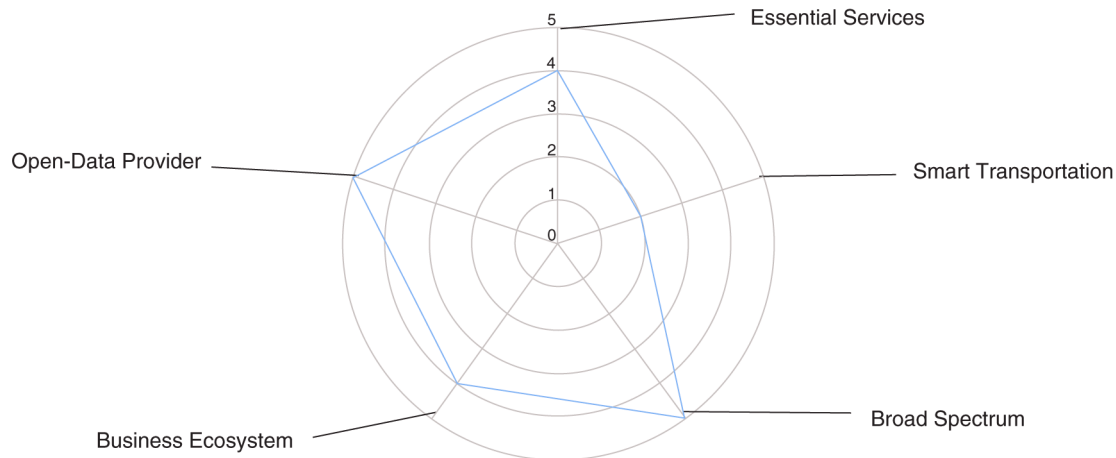
Figure 4. A radar graph showing the emphasis of Peterborough's smart city development.

Chart 3: Prevalence of Emerging Smart City Types

Business Ecosystem
12.7%

Broad Spectrum
23.7%

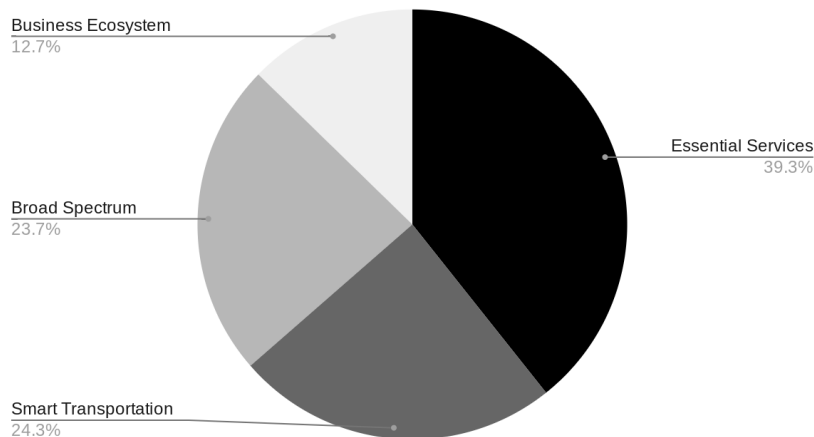Essential Services
39.3%

Smart Transportation
24.3%

Figure 5. The prevalence of emerging smart city types.

section is an overview of the general trends in the development of the smart city. The following highlights emerging technologies and practices with regard to their potential uses in the near future. Next is a more detailed analysis of the intended smart city projects divided into the four-types. Each type has been subdivided by specific projects taking place and their prevalence is discussed below.

Essential services. Within this group, the most prevalent form of smart city project is split between the installation of 5G networks/updating the internet to full-fibre capability and the infusion of council operations and smart city technology (Figure 6). Upgrading council operations include the digitalization of how residents correspond with the council, the adoption of 'digital first strategies' or seeking out digital means for the

streamlining of council operations and the development or expansion of operation centres. An interesting development is the relative popularity of AI technologies or machine learning, specifically within the various councils plans. The United Kingdom is not set for the full autonomisation of council services just yet, but major cities such as London, Newcastle and Manchester are all researching the place of AI within their cities. None of the cities researched for this paper are intending to install AI technology in the immediate future, yet it has already been rolled out in several Chinese cities vis-a-vis facial recognition software such as *Dragonfly Eye* and *Face++* imbedded within Alibaba's City Brain[45]. There is a well-established debate concerning the utilization of AI and it must be highlighted that London is intending to establish a set of ethical guidelines[14].
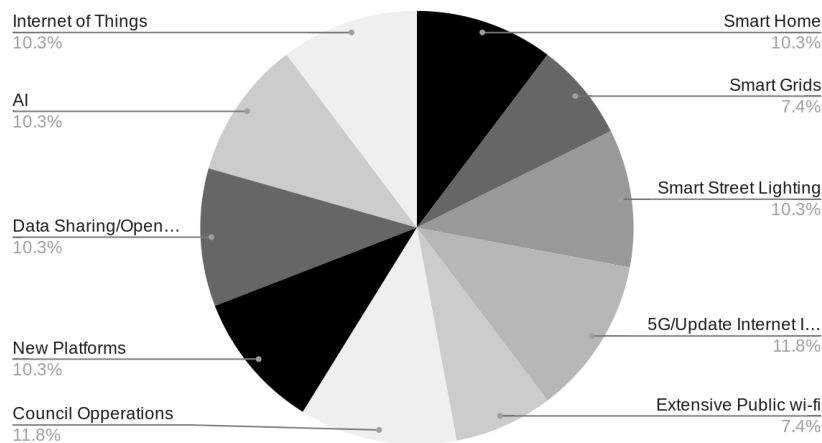
Chart 4: Essential Services

Figure 6. Essential services.

Smart transportation. How is the transportation infrastructure of the UK's cities set to change? As can be seen in Figure 7, the most ubiquitous smart transportation development is the proliferation of electric vehicle (EV) charging options. The rollout of EV charging is the most common strategy amongst all of the cities researched, with 13 cities explicitly stating that they want to increase the opportunities to charge EV's and some cities such as Exeter wanting to replace all council vehicles with EV's by 2030. Another element which is surprisingly prevalent is the testing and research into connected and autonomous vehicles (CAM). Bristol, Milton Keynes, Oxford and Cambridge are all leading the way in the research of CAM technology with Oxford leading the way with the Culham Science Centre open as a testbed and the Oxford Robotics Institute developing AI technology "on real vehicles in real-hard places"[46].

Broad spectrum and business ecosystems. The broad spectrum grouping offered up some intriguing results (Figure 8). Just under a half (46.3%) of the analyzed projects which fell within this group focused on creating 'smart citizens' via improving resident's health and education, a topic that will be discussed in detail in the concluding section. As with the previous two groups there is a significant interest in researching and working towards distant goals, such is the case here with the previously eluded to circular economy. The final group of business ecosystem had the smallest overall proportion of projects - 22 out of 173, yet there are some interesting findings (Figure 9). There are examples of different smart cities working together in 'innovation clusters'. The finest example of this is the intended Cambridge-Milton Keynes-Oxford Arc where the three locations intend to work together on developing CAM technology. According to MK50, Milton Keynes' development roadmap, "the arc is already the home of a globally competitive cluster in cutting-edge transport solutions [and] offers the potential to strengthen – significantly – the UK's international competitive advantage in a wide range of emerging technologies"[47]. This penultimate section highlights the shape of the smart city to come. The concluding section takes a deeper look into the more

common and emergent smart city technologies and practices that purport to becoming more established within UK cities over the coming decade.

Discussion
The U.K Smart City in 2030
This paper has chartered a course through the present and towards the future, investigating the smart city in its current state and where it will be headed from an analysis of publicly available literature. This final section will look into a handful of the most prevalent in emerging themes and technologies which will become ubiquitous in the United Kingdom.

5G. The first technological development to be investigated is 5G networking capability. By the summer of 2020 there should be a total of 43 towns and cities with 5G capability[48]. Yet, the roll out of 5G has not been smooth. There have been protests[49] and the rollout of 5G in the UK has even led to a major political controversy. In April 2019 a leak sprung from the National Security Council (NSC) revealing that during a meeting it was discussed "that Huawei could be given work on "non-core" elements of the 5G network"[50]. Huawei, a Chinese company has won over half of the 5G installation contracts in its homeland, with the countries "largest telecommunications operator China Mobile [awarding] half of its 5G network equipment contracts to Huawei Technologies"[51]. However, in the UK "there are fears that giving the Chinese company a key role could open the UK network to espionage"[52]. Huawei has also been added to a United States trade blacklist which has meant that "a decision on whether Huawei should be allowed into the UK's 5G network infrastructure [being] postponed [...] deferring a possible row between Boris Johnson and Donald Trump"[53]. Protests, international diplomatic spats, Security Council leaks; 5G has proven to be a source of controversy, yet what does it mean for the smart city?

According to Gibbs, 5G "promises much higher connection speeds, lower latency (response times) and to be more reliable

Chart 5: Smart Transportation

MaaS
14.3%

Electric Vehicle Cha…
31.0%

CAM/Driverless Vehi…
19.0%

Integrated Ticketing
16.7%

Smart Traffic Manag…
19.0%

Figure 7. Smart transportation.

Chart 6: Broad Spectrum

Digital Twins/City M…
9.8%

Living Labs
4.9%

Circular Economy
19.5%

Digital Education
26.8%

Environmental sensi…
19.5%

Health
19.5%

Figure 8. Broad spectrum.

Chart 7: Business Ecosystem

City Branding
13.6%

Crowdfunding
13.6%

Innovation Hubs/Ch…
36.4%

Smart Innovation Cl…
36.4%

Figure 9. Business ecosystem.

than the creaking 4G networks we have now"[54]. What this means for the smart city is the possibility to proliferate the scope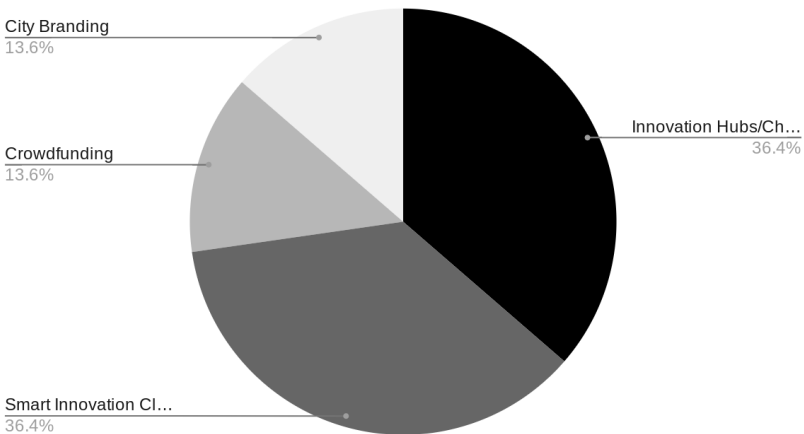 of IoT technology and its interconnectedness, vis-a-vis a fully comprehensive 5G network an entire city and the infrastructures/ entities which inhabit it are connected to one another[55]. It will derive from a 'central server' which is connected to a number of 'local servers', who in turn provides the signal to two delivery options: macro or multiple input, multiple output (MIMO) antennas and small cells which use new millimetre wave (mmWave) frequencies[55]. The small cells are of interest here. Rather than offering a huge span of connectivity as seen with MIMO, the small cells and the millimetre wave it emits has a very weak signal, however if one was to have multiple small cells and arrange them in a sequence, seamless connectivity would be achieved. What is of interest for the smart city not only lies in the increased connectivity and the provision of the Internet of Things, but how these small cells will be distributed throughout the city.

The challenging of ubiquitous infrastructure. Every city is full of objects that are taken for granted and paid little attention; lampposts, benches, trees for example, but they all play a role in the city. However, the mono-functionality of these infrastructures is soon to become a thing of the past. Theo Blackwell, the aforementioned Chief Data Officer for the City of London, has described how the 'humble' lamppost, in the future "could charge electric vehicles, monitor a broad range of environmental issues such as noise and air quality, increase connectivity at a hyper-local area, improve public Wi-Fi and provide CCTV to improve public safety"[56]. The lamppost is also "an important publicly-owned asset for the roll-out of 5G – which will require hundreds of thousands of small installations across London – in coming years"[56].

Soon the lamppost will not only be a light source but a platform enabling the connected city, the same can be said of traffic lights, bus stops and pavements. What is happening here with the modification of these ubiquitous infrastructures is, in the parlance of Martin Heidegger, a *challenging*. To explain challenging Heidegger draws upon the example of the river Rhine. The Rhine for centuries past has been a natural entity until a hydro-electric dam was installed. The rivers standing altered, from a natural phenomena to the provider of electricity:

> "*The Rhine to [supply] its hydraulic pressure, which then sets the turbines turning. This turning sets those machines in motion whose thrust sets going the electric current for which the long-distance power station and its network of cables are set up to dispatch electricity.*"[57]

The river has been 'challenged' by man to produce electricity and thus, its essence has changed. The same can be said of the everyday, ubiquitous objects which function in the city. In the emerging smart city, the lamppost that only provides light is redundant; now it needs to be a platform for 5G small cell networking, a base for environmental and meteorological sensing, an outlet for EV charging and so on. There is an incentive for cities to expand and entrench the roll out of sensing technology

and ubiquitous infrastructures, as the more prolific the sensing of an environment and the more granular and rich the data collected, the more useful it becomes for the city.

EV charging and smart traffic management. Another infrastructure which is not currently ubiquitous, but shall become so, is the electric vehicle (EV) charging point. Electric vehicles are rapidly becoming more common, with the number of EVs quadrupling in the past 4 years, with an approximate 246,000 electric cars on UK roads in 2019 and 27,881 charging points nationwide[58]. As referred to above, the most common form of emerging smart city infrastructure is the EV charging point. There are a number of different types of charging entering the market, below is a selection of them:

- Lamppost Charging: "There are 700,000 lamp-posts in London alone, and about 7.5 million across the country, [...] the standard lamp-post is connected to a 25-amp supply. If they have gone over to LED, then that leaves 24 amps for charging cars. "You will be able to get around 20 miles of driving for every hour of charging at a lamp-post"

- Induction Pads: The idea is that the car is simply stopped over a mat of about 1 m^2 square, placed like a manhole in the road outside your house and connected to the lamp-post. The mat transmits power through the air to another mat fitted under the car, using inductive technology, like an electric toothbrush.

- The Connected Curb: For example, there are curbside charging units dubbed "Armadillos" which are made from recycled tires. There are "Geckos", which are charge points that can be attached to existing street furniture such as bollards and signs, and then there are "Limpets", which are wall-mounted units. These bits of kit are designed to have a low visual impact and are fitted with sensors and gauges that mean they can also provide local authorities with real-time data on traffic, weather and air conditions. In addition, they act as ultra-fast wifi points.

- Dundee Fast Charging Hubs: This week (5/10/2019) Dundee opened its latest set of 20 fast-charging bays on top of a city centre multi-story car park – largely powered by solar panels. The city is by far the most advanced in the UK in switching to electric vehicles, with 20% of local taxis already entirely electric[39].

Another form of smart transportation in use is smart traffic monitoring. During the summer of 2019 Cambridge's train station was being upgraded, which meant that a main thoroughfare over the railway had to be closed during the work's duration, resulting in increased congestion. The Mill Road bridge closure (to road traffic, the paths were still open to pedestrians and cyclists) presented Smart Cambridge with an ideal scenario to test their smart transportation systems:

> "*Smart Cambridge have installed 15 traffic sensors, and the City Council have put 7 air quality sensors, on and around Mill Road to capture data that can monitor any changes to road usage and air quality, and the impact on surrounding roads as a consequence of the closure.*"[59]

The results of the bridge's closure to road traffic were illuminating. On Mill Road the number of cars using it daily fell by 44% and the number of goods vehicles by 54%, whilst the numbers of pedestrians and cyclists gradually increased[59]. However, with the Mill Road bridge being closed, there was a knock-on effect for other streets. The sensors revealed that there was "a relatively significant increase in traffic" on other roads[59]. Before the closure of the bridge "the Smart team provided the Signals team with the vehicle count data"[59], meaning that those who control the traffic light signals across the city had vehicular flow information. After they noticed the traffic increase on Cherry Hinton Road, The signals team "used the system" which controls the coordination of traffic signals along certain roads and changed the timings to give more time for traffic on Clifton Road to get through the traffic lights[60]; this "reduced delay and congestion on Clifton Road – this was a direct result from better understanding of the traffic flow movements"[59]. This example highlights how the utilization of a sensory network and the appropriate infrastructures can make the city work more efficiently.

Smart citizens: education in the smart city. As referred to in the early stages of this work, Rob Kitchen asserts that "a smart city is one whose economy is increasingly driven by technically inspired innovation, creativity and entrepreneurship, enacted by *smart people*"[9]. The 'smart people' of the smart city is an ambiguous proposition, however Alberto Vanolo, a critical scholar of the smart city argues that "the citizens [who] are expected to live in a smart city are supposed to be rather homogeneous" i.e. digitally educated, a possessor of a smartphone, someone who constantly generates data and feedback about everything in her/his daily[60]. A question thus arises: how do smart cities get smart citizens?

From the analysis carried out within this paper, one of the most widespread smart city strategies is the education of citizens, be it at primary school, secondary school or the education of adults. Figure 10 demonstrates the spread of smart educational programmes – here termed 'digital skills'. There was a total of 31 different digital educational projects, and these have been split into four groups: children, school leavers and young adults, apprenticeships and adult/community. The largest proportion of intended education comes via focusing on those who are to leave secondary education. Examples of these adolescent focused initiatives include London's Digital Talent Programme[14], Manchester's Digital Talent Pipeline[61] and Cardiff's pledge to "support the development of the new curriculum for Wales, with a focus on key skills such as digital literacy"[62].

Despite the largest focus falling onto those who are setting off on their career, there is also a large focus on those who wish expand theirs. Adult education in the smart city is premised on two overriding themes, the aforementioned career change and the bridging of 'digital exclusion'. It has long been the case that the "extension of ICTs [is] far from being socially, geographically or culturally neutral"[63] and this is a phenomenon that, according to their own declarations, cities want to overcome. The city of Manchester notes that "digital exclusion is closely linked with social exclusion and has a real impact for our residents"[61], they therefore raise the mooted possibility of "utilizing GM's devolved adult education budget to support basic digital literacy"[61]. Another city which intends to help initiate the digitally illiterate is Bristol, with their mission to have "50% of schools [with] spaces which double as a community resource, for example offering out of hours adult education, advice and support, or use of outdoor space [and] all adults [having] the opportunity to access support to learn digital skills for life and work" by 2032[64].

Another element of citizenry education concerns the uptake of sustainable practices. There are 13 projects concerned with shaping the environmental credentials of their citizens and as can be observed in Figure 11, the majority of these projects are focused on engaging adults and communities. A difference with

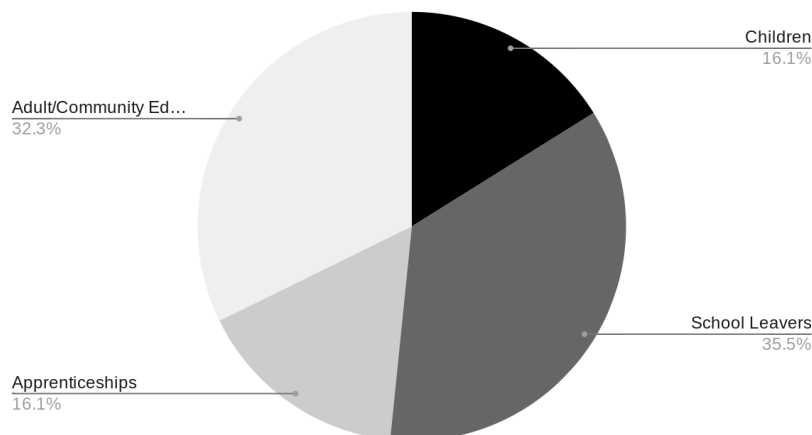Chart 8: The Focus of Proposed Digital Skills Initiatives

- Children 16.1%
- School Leavers 35.5%
- Apprenticeships 16.1%
- Adult/Community Ed... 32.3%

Figure 10. The focus of proposed digital skills initiatives.

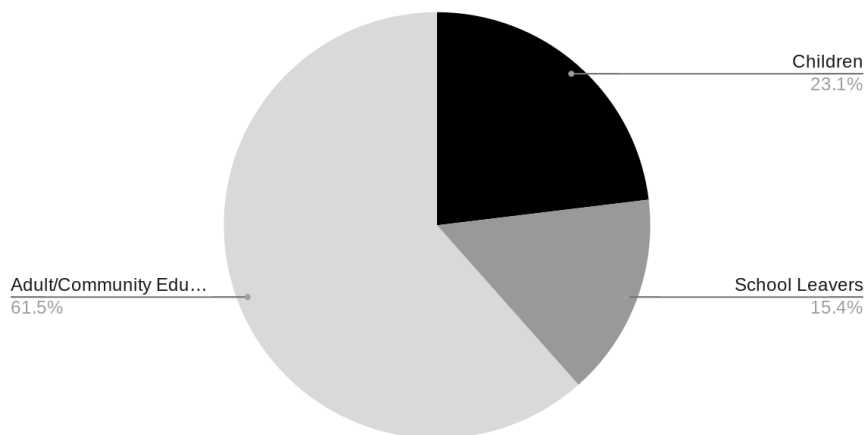Chart 9: The Focus of Proposed Sustainability Education Initiatives

Figure 11. The focus of proposed sustainability education initiatives.

the above, digital skills form of education is its delivery, for sustainability education is a less formal affair than the previous, it is premised upon the learning of practices and general knowledge rather than the attainment of formal skills. Examples include Exeter, which is a city that has pledged to be carbon neutral by 2030 and has therefore "initiated programmes to assist residents to adopt more sustainable and healthy food habits, including the reduction of meat consumption to sustainable levels"[65] and the Scottish Smart Cities Circular Economy initiative with their plan to "engage citizens and support behavioral changes necessary to the Circular Economy"[66].

On towards the future. These are all examples of what is to come in the smart city. It is likely that in a decade's time, one could be walking along a street, potentially towards an evening class on how to write computer code, whilst living amongst a connected 5G cloud, their smartphone skipping from lamppost small-cell-connection to lamppost small-cell-connection. A steady stream of electric vehicles whirr past their right hand shoulder, separated by vehicles tethered to Armadillos and lampposts by errant charging cables. On bin collection days, the lorries are plastered with pledges towards the circular economy, whilst collection is carried out on time, thanks to the effective management of the city's traffic. At the same time a debate rages over the first public tests of autonomous vehicles on the city's road network and the first trials of artificial intelligence in dealing with resident enquiries to the council, who try to assuage the public's fears, but some protest and petitions are made.

This paper started with four questions. Firstly, what current technologies are prevalent in the British smart city? The most widespread technological development is the provision of open data sets, with multiple examples of smart technologies emerging. Subsequently, what practices are currently embedded within the smart city? In terms of developing the smart city, a number of locations lean on the fostering of innovation via startups and

SMEs, especially within innovation hubs. Less common, but still prevalent is the use of citizen engagement as exemplified in Oxford, Newcastle and Edinburgh. Looking forward, in what direction is the smart city heading? Within the next decade, a major theme will be the increased sensing of the city working in conjunction with increased network capability and 5G. Finally, what are the emerging technologies and practices most prevalent in the UK smart city? British residents are most likely to see the proliferation of 5G networks across the country alongside a greater uptake and acceptance of electric vehicles. For city councils, the ability to harness more data will be pursued with gusto, therefore it is expected that the roll out of the IoT and smart objects throughout the urban realm will become apparent, this will be in conjunction with increasing opportunities to enhance digital skills either at the schooling/higher education level or into adulthood.

As with any prediction, there is a possibility of inaccuracy, however in this case these predictions are based upon the pledges and, in a certain sense, promises of multiple city authorities. One thing which can be expected however is the city will visually not change drastically with these smart developments. Aside from more electric vehicles and the sending up of 5G antennas, there are set to be few noticeable alterations to the city fabric, yet what is set to change occurs behind the scenes, there is indeed great potential for the city's functionality to alter drastically with the development of the aforementioned technologies.

This paper has served to provide a sketch of the United Kingdom's smart city terrain by analysing what exists and what is set to do so. An element of UK smart cities is that they exist as both physical and speculative entities simultaneously. The hubris of many councils, institutions and enterprises, who proclaim the testing of an emerging technology as a breakthrough in order to proclaim themselves on the cutting edge of urban development, muddies the waters of what is actual in the

smart city and what is to be. This explains the approach of this paper and research going forward. This is the first offering of a project focused upon researching the smart city as a system of systems, with parallel focuses upon notions of co-design and the development of smart cities with the diverse range of actors inherent within their existence.

Data availability

Underlying data

Loughborough University: Dataset-UK Smart Cities Present and Future (2020). https://doi.org/10.17028/rd.lboro.11618538[17].

File "Data Set_UK Smart Cities Present and Future (2020).xlsx" contains the following underlying data:

- The ranking system used in this paper.

- Links to the web pages where said ranking originated.

- A log of the various stakeholders inherent with each smart city project, separated into external stakeholders (Technology Vendors, NGO's, International Government Organisations and National Government) and internal stakeholders (Local Government and University/ Academia).

- A repository of the roadmaps and strategy documents used, along with an analysis of each one and the ranking schema used for analysing the roadmaps and strategy documents.

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

References

1. SCIS: **Smart Cities and Community Lighthouse projects.** 2019; [Accessed 03/12/2019].
   Reference Source

2. Frost & Sullivan: **Smart Cities.** 2019; [Accessed 03/12/2019].
   Reference Source

3. UKRI: **CONNECTED PLACES CATAPULT CORE DELIVERY.** 2019; [Accessed 03/12/2019].
   Reference Source

4. Mine-Thompson E: **What makes a city 'smart'?** *Int J Archit Comput.* 2016; **14**(4): 358–371.
   Publisher Full Text

5. Manville C, Cochrane G, Cave J, *et al.*: **Mapping Smart Cities in the EU.** 2014; [Accessed 01/12/2019].
   Reference Source

6. Yufeng K: **15 deaths from dengue so far this year, highest in a decade.** 2019; [Accessed 03/12/2019].
   Reference Source

7. Smart Nation SIngapore: **OneService App.** 2019; [Accessed 24/01/2020].
   Reference Source

8. Smart Nation Singapore: **Drones to Survey Dengue Hotspots.** 2019; [Accessed 03/12/2019]
   Reference Source

9. Kitchin R: **Making sense of smart cities: addressing present shortcomings.** *Camb J Reg Econ Soc.* 2015; **8**(1): 131–136.
   Publisher Full Text

10. Cosgrave E, Arbuthnot K, Tryfonas T: **Living Labs, Innovation Districts and Information Marketplaces: A Systems Approach for Smart Cities.** *Procedia Comput Sci.* 2013; **16**(2013): 668–677.
    Publisher Full Text

11. Calzada I, Cowie P: **Beyond Smart and Data-Driven City-Regions? Rethinking Stakeholder-Helixes Strategies.** *Regions Magazine.* 2017; **308**(4): 25–28.
    Publisher Full Text

12. Selada C: **Smart Cities and the Quadruple Helix Innovation Systems Conceptual Framework: The Case of Portugal.** 2017; 211–244. [Accessed 09/06/2020].
    Publisher Full Text

13. Sennett R: **Together: The Rituals, Pleasures and Politics of Cooperation.** Penguin, London. 2013.
    Reference Source

14. Greater London Authority: **Smarter London Together Roadmap.** 2018; [Accessed 03/12/2019]
    Reference Source

15. Tang Z, Jayakar K, Feng X, *et al.*: **Identifying smart city archetypes from the bottom up: A content analysis of municipal plans.** *Telecomm Policy.* 2019; **43**(10): 101834.
    Publisher Full Text

16. Science Daily: **Grouping 'smart cities' into types may help aspiring city planners find a path.** 2019; [Accessed 03/12/2019].
    Reference Source

17. Brown W, King M, Goh YM: **Dataset-UK Smart Cities Present and Future.** *figshare.* Dataset. 2020.
    http://www.doi.org/10.17028/rd.lboro.11618538.v1

18. Department for Business Innovation and Skills: **Open Data Strategy 2014-2016.** 2014; [Accessed 03/12/2019].
    Reference Source

19. da Chuna I, Selada C: **Creative urban regeneration: the case of innovation hubs.** *Int J Innovation and Regional Development.* 2009; **1**(4): 2009.
    Publisher Full Text

20. Sensor City: **Sensor City.** 2019; [Accessed 03/12/2019].
    Reference Source

21. Blackwell T: **London's road to smart cities.** 2019; [Accessed 03/12/2019].
    Reference Source

22. REMOUrban: **Lighthouse Cities.** [Accessed 03/12/2019].
    Reference Source

23. REMOUrban: **Nottingham's Ultra Low Energy Homes are the Stars of Two International Conferences.** 2019; [Accessed 03/12/2019].
    Reference Source

24. Edinburgh Living Lab: **Projects.** 2019; [Accessed 03/12/2019].
    Reference Source

25. Flood Network: **Flood Network.** 2019; [Accessed 03/12/2019].
    Reference Source

26. Urban Observatory: **Sense My Street.** 2019; [Accessed 03/12/2019].
    Reference Source

27. Smart Belfast: **Amazing Spaces, Smart Places pilot projects in Belfast Parks.** 2019; [Accessed 03/12/2019].
    Reference Source

28. Futurecity Glasgow: **Glasgow Operations Centre.** 2019; [Accessed 03/12/2019].
    Reference Source

29. Srnicek N: **Platform Capitalism.** Polity Press, Cambridge. 2017.
    Reference Source

30. Connecting Cambridgeshire: **Data- Intelligent City Platform.** 2019; [Accessed 03/12/2019].
    Reference Source

31. Johnston SJ, Basford PJ, Bulot FMJ, *et al.*: **City Scale Particulate Matter Monitoring Using LoRaWAN Based Air Quality IoT Devices.** *Sensors (Basel).* 2019; **19**(1): pii: E209.
    PubMed Abstract | **Publisher Full Text** | **Free Full Text**

32. Jeffries D: **Should councils be investing in free public Wi-Fi networks?** 2011; [accessed 03/12/2019].
    Reference Source

33. City Fibre: **Gigabit Cities.** 2019; [Accessed 03/12/2019].
    Reference Source

34. Digital York: **Digital York.** 2019; [Accessed 03/12/2019].
    Reference Source

35. Jefferson-Brown N: **Shambles in York joins in the digital revolution.** 2019; [Accessed 03/12/2019].
    Reference Source

36. Brighton and Hove Bus and Coach Company: **Contactless payments and Tap On, Tap Off.** 2019; [Accessed 03/12/2019].
Reference Source

37. Yamamoto Y: **Bijlmer Euro: Tracing Money in the Local Economy.** 2015; [Accessed 03/12/2019].
Reference Source

38. Carell S: **Dundee's green revolution: council-run charging hubs and electric cabs.** 2019; [Accessed 03/12/2019].
Reference Source

39. Collinson P, Jones R: **Powering ahead: six new ways to charge an electric car.** 2019; [Accessed 03/12/2019].
Reference Source

40. The Mill: **Projects.** 2019; [Accessed 03/12/2019].
Reference Source

41. Future Peterborough: **Projects.** 2016; [Accessed 03/12/2019].
Reference Source

42. Girardet H: **Cities, People, Planet.** 2000; [Accessed 03/12/2019].
Reference Source

43. Future Peterborough: **Share Peterborough.** 2016; [Accessed 03/12/2019].
Reference Source

44. Abu-Lughod J: **The Islamic City--Historic Myth, Islamic Essence, and Contemporary Relevance.** *Int J Middle East Stud.* 1987; **19**(2): 155-176.
Publisher Full Text

45. Alibaba Cloud: **City Brain.** 2019; [accessed 03/12/2019].
Reference Source

46. Mobile Robotics Institute: **Mobile Robotics Institute.** 2019; [Accessed 03/12/2019].
Reference Source

47. MK50: **Milton Keynes: Making a Great City Greater.** 2016; [Accessed 03/12/2019].
Reference Source

48. 5G. co.uk: **5G Coverage.** 2019; [accessed 03/12/2019].
Reference Source

49. Hearn A: **How baseless fears over 5g rollout created a health scare.** 2019; [Accessed 03/12/2019].
Reference Source

50. Woodcock A: **Huawei: Unprecedented leak from National Security Council 5G meeting sparks demands for investigation.** 2019; [Accessed 03/12/2019].
Reference Source

51. Tao L: **Huawei wins half of China Mobile's 5G network contracts while Ericsson picks up a third.** 2019; [Accessed 03/12/2019].
Reference Source

52. BBC News: **Huawei 5G row: Ministers demand leak inquiry.** 2019; [Accessed

53. Wintour P: **UK government postpones Huawei 5G decision.** 2019; [Accessed 03/12/2019].
Reference Source

54. Gibbs S: **What is 5G and when can I get it in the UK?** 2019; [Accessed 03/12/2019].
Reference Source

55. EMF Explained: **How Does 5G Work?** 2019; [Accessed 03/12/2019].
Reference Source

56. Blackwell T: **How the 'humble lamppost' means smarter streets — through London's big collaboration with fellow European cities.** 2019; [Accessed 03/12/2019].
Reference Source

57. Heidegger M: **The Question Concerning Technology.** [Basic Writings] Routledge, Abingdon. 1977[2011].
Reference Source

58. Next Green Car: **Electric Car Market Statistics.** 2019; [Accessed 03/12/2019].
Reference Source

59. Connecting Cambridgeshire: **Mill Road Case Study – Cambridgeshire County Council Signals Team.** 2019; [Accessed 03/12/2019].
Reference Source

60. Vanolo A: **Is there anybody out there? The place and role of citizens in tomorrow's smart cities.** *Futures.* 2016; **82**: 26–36.
Publisher Full Text

61. Greater Manchester Council Authority: **The Greater Manchester Digital Strategy 2018–2020.** 2018; [Accessed 03/12/2019].
Reference Source

62. Cardiff Caerdydd: **Capital Ambition.** 2017; [Accessed 03/12/2019].
Reference Source

63. Graham S: **Bridging Urban Digital Divides? Urban Polarisation and Information and Communications Technologies (ICTs).** *Urban Stud.* 2002; **39**(1): 33–56.
Publisher Full Text

64. Bristol One City: **One City Plan.** 2018; [Accessed 03/12/2019].
Reference Source

65. Exeter City Futures: **Sustainable Resources & Biodiversity.** 2019; [Accessed 03/12/2019].
Reference Source

66. Smart Cities Scotland: **Smart Cities Scotland Blueprint.** 2016; [Accessed 03/12/2019].
Reference Source

Open Peer Review

Current Peer Review Status: ✓ ✓ ✓

Version 2

Reviewer Report 21 September 2020

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✓   **Igor Calzada** (iD)
        University of Oxford, Oxford, UK

This article shows an interesting comparative analysis of 26 cities within the UK. Particularly remarkable including referenced cases such as Glasgow and Bristol. I wonder if these two references could be beneficial to reinforce the main argument insofar as they provided a comparative international standpoint on smart cities. I may suggest the authors to include these two references entirely align with the content of this article: [1,2].

In summary, the article is an interesting contribution to the field of the smart cities as such. This review has attempted to improve this article that the reviewer considers is worth reading.

References
1. Calzada I: The Techno-Politics of Data and Smart Devolution in City-Regions: Comparing Glasgow, Bristol, Barcelona, and Bilbao. *Systems*. 2017; **5** (1). Publisher Full Text
2. Calzada I: Smart City Citizenship. *Elsevier*. 2020.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Smart Cities, Data Ecosystems, City-Regions, Political Geography, Techno-Politics of Data, Data Co-operatives and Platforms, Social Innovation, Algorithmic Nations

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 14 April 2020

https://doi.org/10.21956/emeraldopenres.14485.r26720

✔ **Anthony Simonofski**

University of Namur, Namur, Belgium

This paper examines the state of advancement of the smart city concept in the UK. In order to do so, the authors first perform a comparison of 26 cities' smart city development by analysing news articles, reports and policy documents. Then, they analyse the smart city plans of 20 cities and to observe the expected emergence of smart city technology.

In "The Smart City Section", the authors make a good attempt at defining the smart city that very interesting to read. This results in presenting different appropriations of the concept. However, I would have liked more insights about the links (complementarities/conflicts) between the considerations (e.g.: is the triple helix model in line with the technological orientation of the concept?). Additionally, I think the authors could fuel this background section with complementary definitions from other considerations of the smart city. Having my own research focus about the concept, I was missing the "participatory" aspect of the smart city as can be founding paper of Hollands in 2008 (Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial?. City, 12(3), 303-320[1].) as well as in other recent works:

  ○ Cardullo, P., & Kitchin, R. (2019). Being a 'citizen'in the smart city: up and down the scaffold of smart citizen participation in Dublin, Ireland. GeoJournal, 84(1), 1-13[2].

  ○ Berntzen, L., & Johannessen, M. R. (2016). The role of citizen participation in municipal smart city projects: Lessons learned from Norway. In Smarter as the new urban agenda (pp. 299-314). Springer, Cham[3].

  ○ Simonofski, A., Asensio, E. S., De Smedt, J., & Snoeck, M. (2019). Hearing the voice of citizens in smart city design: the citivoice framework. Business & Information Systems Engineering, 61(6), 665-678[4].

  ○ I can provide the authors with more background papers if needed. This seems relevant as citizen engagement was highlighted in cities such as Oxford, Newcastle and Edinburgh.

In the "methods" section, the authors present the research design they applied in a clear and structured manner. I would have like to read more insights on:

  ○ The choice of using the formalization of Tang et al. instead of other. Completeness? Ease of use?

  ○ The rationale between the selection of these 26 cities. Was it based on availability of information? On existing rankings?

  ○ What drove the choice of examining 20 extra locations on top of the 26 cities? Once again, how were they selected, why, etc.

The results part of the paper is clear and quite interesting to read. It is a structured way to present the current state of smart cities in a country and I found it exciting to read.

The discussion section, by highlighting policy domains and technological focuses that will define the future of the smart city, is interesting but seems to overlap with the results section. For instance, why aren't the Figures 10 and 11 presented in the Results section? I would also have liked to read a:

- "Limitations" section where the authors could discuss the choices that drove their study (Was the framework used appropriate? Could other data sources like interviews be relevant?)

- "Further Research" section where the authors could suggest leads for interested research to perform similar comparison of the city. I also think that this comparison work would allow to identify "clusters" of cities, depending on how they appropriate the concept.

Minor comment: I spotted this typo in the paper on p.8: This the tacit opposite of Peterborough.

To conclude, I found this piece of research to be really interesting to read and I congratulate the authors for the impressive and rigorous study. The authors present in a structured way how the smart city concept is appropriated in the UK through by using a relevant framework and by presenting their results clearly. I think that his paper is relevant for practitioners as well that want to "demystify" the abstract smart city concept. The comments (theoretical background, more insights on methodological choices, discussion of limitations and avenues for further research) above are suggestions to the authors that would, in my opinion, increase the strengths of this paper, especially in its relevance for researchers that would like to build upon the research.

References

1. Hollands R: Will the real smart city please stand up?. *City*. 2008; **12** (3): 303-320 Publisher Full Text

2. Cardullo P, Kitchin R: Being a 'citizen' in the smart city: up and down the scaffold of smart citizen participation in Dublin, Ireland. *GeoJournal*. 2019; **84** (1): 1-13 Publisher Full Text

3. Berntzen L, Johannessen M: The Role of Citizen Participation in Municipal Smart City Projects: Lessons Learned from Norway. 2016; **11**: 299-314 Publisher Full Text

4. Simonofski A, Asensio E, De Smedt J, Snoeck M: Hearing the Voice of Citizens in Smart City Design: The CitiVoice Framework. *Business & Information Systems Engineering*. 2019; **61** (6): 665-678 Publisher Full Text

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 14 April 2020

https://doi.org/10.21956/emeraldopenres.14485.r26673

? Igor Calzada ⓘD

University of Oxford, Oxford, UK

This article analyses several UK cities regarding their smart city projects.

Despite the article could well align with the academic debate on smart cities and contribute to the literature, I found several elements in the manuscript that recommends Revise and Resubmit (R&R).

1. From the early beginning of the article, in the abstract, it is not clear whether there are 20 or 26 cities those examined by this paper, which essentially prepares the reviewer for not having understood well or, probably worse, to perceive a remarkable inaccuracy just when the paper starts. To illustrate this, here the sentence that can be found in the first paragraph, which reinforces the mess and the potential misinterpretation:

This is done by analysing the level of actual progress made in 26 individual locations according to a five-point ranking scale. To accompany this, a policy analysis of 20 locations and their respective roadmaps, policies and strategies concerning the development of smart, digital and sustainable technologies and practices is provided in order to observe progress made and ascertain the future direction.

2. In addition to this, from the early beginning is not clear which is the specific research question regarding the examination of smart city projects. What will this examination focus on? The four research questions presented in page 3 are rather generic and they do not provide a clear idea of the outcome of this paper. I suggest reviewing and rephrasing them. Prevalent, embedded, direction, and again prevalence are the four aspects being addressed in page 3.
We recommend relocating the questions much earlier.

3. The structure is rather confused at the end of the introduction. A bit later, the reference to lighthouse projects is wrong, there are not 14 projects and 40 cities involved at the moment. This

paper must provide updated and rigorous references.

After citing Kitchin, the explanation about the Triple Helix is rather out of date. We suggest updating this paragraph by using references to Penta Helix:

Calzada, I. & Cowie, P. (2017), Beyond Data-Driven Smart City-Regions? Rethinking Stakeholder-Helixes Strategies[1].

Then later, the article introduces the term 'silos' without any relationship with the main research literature on smart cities, despite the fact in the policy interventions is highly discussed.

4. Methodologically speaking, the five smart city projects typology is rather arbitrary and is not clear where does this come from. Actually is not even align with H2020 SCC policy framework as such. Moreover, the structure within the same paragraph is not well presented. The typology is very normative starting from 'essential services'. Who decide whether 5G must be consider essential? There is an absent of techno-political analysis on smart cities.

When presenting what Smart Cities are, there are important references being missed and also the current debate on data. We suggest incorporating several updates on smart city current debates to make this manuscript timely and rigorous.

- Willis and Aurigi (2020). Routledge Companion to Smart Cities. Routledge[2]

- **Calzada, I.** & Almirall, E. (2020), Data Ecosystems for Protecting European Citizens' Digital Rights, *Transforming Government: People Process and Policy (TGPPP)* **14**(2)[3].

- Komninos and Kakderi (2020). Smart Cities in the Post-algoritmic era: Integrating Technologies, Platforms and Governance. Edward Elgar[4].

- **Calzada, I.** (2018) From Smart Cities to Experimental Cities? In Vincenzo Mario Bruno Giorgino and Zachary David Walsh (eds), *Co-Designing Economies in Transition: Radical Approaches in Dialogue with Contemplative Social Sciences.* Cham: Palgrave Macmillan. pp. 191-217[5].

- **Calzada, I.** (2018), (Smart) Citizens from Data Providers to Decision-Makers? The Case Study of Barcelona. *Sustainability* **10**(9): 3252. DOI: 10.3390/su10093252. Special Issue: Big Data Research for Social Sciences and Social Impact[6].

5. The paper presents a Google search as a methodology and thereafter presents directly results. We recommend a more robust methodology and a less normative categorisation of SC projects' types. The way two Charts 1 and 2 are presented is very confused.

To sum up, the paper reveals not insignificant issues and flaws i.e. even not presenting the final section of Conclusion or Final Remarks.

Thus, we firmly recommend a deep re-structuring from scratch. In addition, the paper must integrate previous suggestions and proceed with a deep analysis. In conclusion, we recommend Revise and Resubmit (R&R). I would be willing to review the new version.

References

1. Calzada I, Cowie P: Beyond Smart and Data-Driven City-Regions? Rethinking Stakeholder-Helixes Strategies. *Regions Magazine*. 2017; **308** (4): 25-28 Publisher Full Text

2. Willis KS, Aurigi A: The Routledge Companion to Smart Cities. *Routledge*. 2020. Reference Source

3. Calzada I: Data ecosystems for protecting european citizens' digital rights. *Transforming Government People Process and Policy*. 2020. Publisher Full Text

4. Komninos N, Kakderi C: Smart Cities in the Post-algorithmic Era. 2019. Publisher Full Text

5. Calzada I: From Smart Cities to Experimental Cities?. 2018. 191-217 Publisher Full Text

6. Calzada I: (Smart) Citizens from Data Providers to Decision-Makers? The Case Study of Barcelona. *Sustainability*. 2018; **10** (9). Publisher Full Text

Is the work clearly and accurately presented and does it cite the current literature?

No

Is the study design appropriate and is the work technically sound?

No

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Smart Cities, Data Ecosystems, City-Regions, Political Geography, Techno-Politics of Data, Data Co-operatives and Platforms, Social Innovation, Algorithmic Nations

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 07 April 2020

https://doi.org/10.21956/emeraldopenres.14485.r26676

✔ **Lasse Berntzen** iD

University of South-Eastern Norway, Kongsberg, Norway

The author presents a forward-looking analysis of the smart city concept based on an investigation of 26 cities in the United Kingdom. The manuscript presents four research questions:

1. What current technologies are prevalent in the British smart city?

2. What practices are currently embedded within the smart city?

3. In what direction is the smart city heading?

4. What are the emerging technologies and practices most prevalent in the UK smart city?

The manuscript starts with an overview of the smart city concept. The author shows several examples that fit under the smart city umbrella. However, the author could have discussed the provision of more efficient (digital) services for citizens and also the opportunities to enhance participation, both political (influencing political decision making) and non-political (co-creation of services, acting as human sensors, etc.)

The author relies on 'four types´ of smart cities: **Essential services** (using infrastructure e.g., for smart healthcare, with emphasis on maintaining and further developing the infrastructure), **smart transportation** (including smart public transport), **broad spectrum** (focus on utilities and environmental monitoring, but also sustainability and citizen engagement) and **business ecosystem** (jumpstart economic activity)

The author has collected valuable data from 26 cities. The inclusion of open data provision is appropriate, since open data may be used by third parties to develop new innovative applications and services. However, the data is based on open sources (Google search) and may not provide the full picture. *A questionnaire-based survey and/or interviews with city officials may have provided additional information since not everything is published on the Internet.*

The use of the four categories may be elusive, since cities may have projects fitting several categories. Therefore, being an "essential services" city does not mean that the city only focuses on "essential services." Therefore, the use of "radar graphs," as shown in figure 3, provides a better understanding of each city.

The examples provided show good examples of how cities strive to become "smarter."

The manuscript adds to a growing corpus of smart city publications and will be valuable for other researchers looking for examples of smart city projects.

The analysis of what is to come is based on a review of documents and provides insight into the development of UK smart cities. Again, *a questionnaire-based survey and/or interviews with city officials may have provided additional information.*

The discussion of AI is exciting. AI will happen, even if it is not highly emphasized in the online documents. AI will automate processes and relieve city officials of routine tasks. Just the opportunity to save costs will be an essential driver. We already see the introduction of chatbots in public services. For smart transportation, I would expect some comments on autonomous transport.

The author finishes by discussing the UK smart city in 2030. The author discusses possible problems related to 5G implementation, the challenging of ubiquitous infrastructure, electric vehicle charging, and smart traffic management and education in the smart city. The observations are valid, but I miss a discussion about the implication for citizen participation (both political and non-political).

The recent Corona-outbreak has forced new ways of communication, both on a personal, institutional, and societal level. Suddenly, collaboration through digital channels is no longer an option, but mandatory. Closed schools and universities push innovation and will impact on the future of communication. My point is that developments may happen faster than expected. Maybe 2030 will be 2025.

The author has presented a well-argued paper that positively will contribute to the growing corpus on smart city literature. It would be nice to see similar analyses from other countries.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Smart cities, Internet-of-Things, e-Participation

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.