Data Platforms for Smart Cities

A Landscape Scan and Recommendations for Smart City Practice

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Executive summary

Smart cities are complex configurations of technology, organisations and people that enable data about the city to be collected and flow to those who plan and deliver services in cities, leading to better urban outcomes for citizens and businesses. Platforms play a critical role in smart cities and in broader digital disruption across all industries. Platforms are essentially mechanisms that enable value exchange between two or more sets of stakeholders. On digital platforms, data may be the primary value exchange (e.g. Facebook) or a by-product and enabler of other types of value exchange (e.g. Uber or eBay). The role of a platform is to match providers of data and services with those seeking these things, while minimising the transaction costs of doing so. These are exciting times, as digital technology has dramatically reduced the transaction costs of making such matches, greatly expanding the scope of platforms.

This report examines platforms for collecting and sharing data relevant to people in an urban context, and the smart city initiatives through which they are being developed. It aims to provide an improved understanding of the socio-technical aspects of city-related data sharing and platform development by exploring the intersection of social, institutional and economic issues due to the rapid growth of data collection. It distils insights and recommendations to inform both the development of a transport mobility application and the development of social and technical architectures for urban data platforms in general.

It is intended to inform practitioners engaged in smart city development work – specifically, in the design and development of the data aggregation and integration mechanisms (urban data exchanges) – by providing insights, highlighting key challenges, and offering recommendations to address these challenges.

This work formed part of a larger project based on the development of a smartphone application through which individuals can choose to gather and share data on their commute while maintaining their privacy (the app and associated provable privacy mechanisms are described in a parallel report).

Landscape scan of existing data platforms and markets

A ‘landscape scan’ was undertaken to explore existing data collection and sharing initiatives, focused primarily around data on human activity in the urban environment. The scan assessed 109, ranging from smart urban initiatives at national, city and neighbourhood scale; to technology vendors, public sector platforms and data market-like offerings (such as Huawei Smart City and London Data Repository); to specific applications. These cases were scattered across Europe, North America, Asia and Australia, spanning several decades, and covered a range of domains (economic, energy, environment, transport, health, safety, security) and a spectrum of social, technical and economic architectures. While the scan makes no claim to be exhaustive, it samples the tremendous diversity of smart city activity. The main findings of the landscape scan are:

- Smart city initiatives use highly variable technology configurations.
- The public sector is the predominant initiator and driver of smart city agendas. The public sector works in partnership with both industry, who acts as technology providers, and civil society – although civil involvement is variable and typically limited.
- A small number of data platforms operated by private sector companies have become dominant in controlling and providing data of use in the urban context.
- Location data is critical for city applications.
- Vertical integration is occurring between physical infrastructure providers (e.g. roads and telecommunications) and sensor and data platform providers, resulting in the locking up of data value chains.
- Increasing horizontal integration is occurring (i.e. integration of different kinds of cross-sector data such as mobility and environmental data).
- The nature of smart city ecosystems is changing, moving from smaller thematic applications often driven by citizens (10 years ago) to an increasing number of sensor-based platform technology offerings from global technology providers.
• Three phases of a data platform lifecycle can be identified (i) initiation (sometimes starting as an app), (ii) establishment and growth of the pot of data within a data market, and (iii) emergence of networked data markets.

Where are the people?

Most smart city initiatives are primarily partnerships between government and industry, with city managers engaging technology providers for solutions or the latter identifying problems that can be addressed via platform infrastructure. In these initiatives, data is typically treated as a technology of governance or as a revenue stream. Citizens are mostly simplistically and one-dimensionally treated as providers of data (and who are typically not fully aware of what data is being collected, and for what purposes it may be used). In one of the more extreme examples, the Songdo Smart City in South Korea built smart city fabric in a greenfield site, and then attempted to entice citizens to move there. A small number of smart city initiatives actively engage civil society, including initiatives in Toronto, Copenhagen and Barcelona. In Copenhagen’s City Data Exchange (CDE) an experimental and collaborative process of development spanning state, industry and civil society was adopted in an attempt to build a community of practice around the exchange. The predominantly top-down, technology-driven approach risks marginalising citizens and creating digital inequities as a small number of public and private sector entities enjoy privileged access to citizens’ data.

In smart cities a triad of sectors – the state (i.e. all levels of government), the market (i.e. private sector) and civil society (i.e. citizens and communities) – each with their own value drivers, contribute to realising smarter and thus better cities. There is a need for an improved social architecture of governance and social engagement to balance the differing value drivers and often competing interests of these three sectors. This report highlights key value drivers and issues within each sector, and the tensions between them.

Recommendations

The report provides two sets of recommendations: the first informs the development of applications that require users to actively opt-in to share their data (section 5); and the second concern broader smart city practice (section 6). These recommendations span social, institutional and economic concerns.

Figure 1 presents key elements of smart cities. It shows data flowing between the data creators/providers/owners and users of data/services through the platform and the data market that it enables. There are three key classes of recommendations that arose from this analysis – societal, economic and institutional (as shown in Figure 1) – which represent complementary approaches to developing efficient and equitable data sharing platforms. The first is social. Cities are inherently social, so smart city initiatives need to deeply engage with citizens, rather than just focusing on the technology and its potential uses by city managers. Co-design is important here, for both genuine engagement and identifying how data can be used to address issues of concern to citizens themselves. It also entails viewing data in a more holistic way, for example, as an extension of individuals and their identity in civil society, thus opening up opportunities for equitable dialogue between citizens who provide data and those who seek to use their data. This will require an educational component and the provision of information about how smart city programs can work. It is also likely to require education and capability building for those developing and implementing the technology to devise a more holistic approach to gathering and sharing data.
Figure 1 Recommendations for smart city practice

The second is economic. The key economic recommendation is to consider smart city data platforms as public utilities that enable access to and appropriate use of data. There are strong economies of scale, and privileged access to such platforms (and their data) can confer significant market power. It is a role of government to provide public utilities such as data platforms (either directly or indirectly), ensuring there is a viable ongoing business model for them. Through these efforts government should seek to ensure the continued creation of public value (for example, through improved public transport), while providing sufficient space, and a level playing field, for the private sector to operate and innovate. The public sector should be wary of entrenching the dominance of specific platforms or providers, and the potential for data to be monopolised.

Finally, institutional recommendations focus on promoting more equitable governance arrangements, which include citizen representation and participation in data collection and use. Where city-related data is provided by multiple parties or sectors for shared benefit, data trusts or cooperative models may be more appropriate than traditional centralised government and/or private sector ownership models. Where city-related data platforms are provided by private sector, government is encouraged to regulate and establish appropriate policy regimes that maximise opportunities to create public value while at the same time ensuring a level playing field for smaller private and community sector organisations to innovate and operate.
1 Introduction

1.1 Purpose and scope

A ‘smart city’ aims to harness data flowing from a variety of sources within the built environment to improve urban management. This report contributes to CSIRO’s Data Driven Cities research mission by considering how data can best be shared and utilised within smart cities. Data is integral to the smart city concept. Sharing data generally enhances its value (as in economic terms it is a non-consumptive resource) but can also generate concerns around privacy and security, and contribute to power imbalances (e.g. companies collecting large amounts of data may gain a competitive advantage over others).

Data sharing is considered to be a socio-technical challenge; thus, this report considers the social architectures – which include governance mechanisms, incentives, expectations and behaviours – required to support efficient and equitable data sharing. This report also explores the notion of smart cities, data and technology platforms, along with the stakeholder values, issues and relationships that comprise smart cities initiatives. It distils insights and recommendations to inform both the development of a transport mobility application and the development of social and technical architecture for urban data platforms in general. A parallel report\(^1\) considers the technical architecture of a mobility application that provides provable privacy, allowing data to be shared without compromising individual privacy.

This report provides a broad context covering smart cities, digital platforms and the data exchanges/data markets that operate on top of these platforms. Within this context a ‘landscape scan’ of smart city initiatives, along with the platforms and technologies that enable them, was conducted (in sections 3 and 4). Based on the landscape scan, reflections on data sharing (Section Error! Reference source not found.) and recommendations for app developers (Section 5) and smart city practitioners (Section 6) are made.

Smart city efforts need to orchestrate complex platform ecosystems that collect data from, and make data available for use by, diverse stakeholders. This report aims to deepen understanding on how the various components and capabilities required to realise smart cities could be assembled by navigating the complex social, institutional and economic concerns raised by the rapid global growth of the ‘Internet of Things’ (IoT) technology and data collected about and from citizens – elements of smart city efforts.

Project context: Measuring mobility

This report forms part of a larger project ‘Urban data markets: Social and technical architecture to ensure efficiency, equity and privacy’. As a first use-case, the project is prototyping a data sharing mechanism centred on citizens’ daily commute data (Figure 2). The project considers the incentives and assurances, which may encourage people to choose to share their data – both transactional data (from their public transport smartcards (e.g. NSW Opal cards)) and related activity (e.g. movement immediately before or after public transport use). A smartphone application (app) is being developed and tested that will collect mobility data on devices of consenting users. Data will be de-identified and aggregated to be shared with others such as researchers (to assist with planning and analysis) and other users (e.g. to provide real-time public transport information).

Our proposed data ecosystem would also provide an architecture to reward users – not just for sharing their data, but also for the transport choices they make – in a transparent, fair, privacy preserving and flexible manner. A scalable system that securely captures the mode of transport adopted by the user – such as walking, cycling, public transport or private vehicle – for each journey could reward the user with ‘credits’ proportional to their positive impact on the environment. This data will be analysed to instantly record the rewards applicable to the user, and post a ‘provable privacy’ preserving transformation feed into the data ecosystem that will be consumed by various city bodies (e.g. Transport, Infrastructure development) to improve their offerings, help reduce the city’s congestion and anticipate future infrastructure issues. The

\(^1\) Urban Data Market: A Privacy Preserving Mobile Application. Raghav Bhaskar, Guillaume Jourjon, and Thierry Rakotoarivelo, Data61.
user might see their rewards accumulate over time in terms of a virtual currency that can be ‘spent’ through various project sponsors (e.g. transport authorities), or alternatively used within the app to access data.

Figure 2 From mobility app to (mobility) urban data market/platform

From a technological perspective the app enables commuters to collect and store personal data on their own mobile phone, providing safe and anonymous access and integration of the data to create potentially valuable insights about transportation patterns. If a critical mass of data could be aggregated by app developers, this data may be of use, and thus of value to service providers, such as New South Wales Transport. Furthermore, these service providers may be inclined to offer incentives, such as discounted fares, to providers of the data.

There are certain challenges that accompany the app and the project. Various ‘competing’ applications do similar things (e.g. Strava). Privacy concerns, sensitivities and disbenefits of data sharing currently loom large. Furthermore, the value proposition of smart cities is that data at scale relating to one aspect of city life can be aggregated, integrated and analysed alongside other data (air quality, energy consumption, socioeconomic differences, employment, etc.) to better understand and service citizens’ needs. But this entails some arrangement – a platform – where data of different sorts can be cached, integrated and leveraged for insights. The social and technical architecture of genuinely heterogeneous and balanced data platforms has not yet stabilised. A range of social, institutional and economic issues trouble the collection, aggregation and use of mobility data. The challenge is to configure data platforms that can support multiple applications and encompass values of equity and reciprocity.
2 Data and the city

According to United Nations research, approximately 55% of the world's population lives in urban centres, and is expected to rise to 68% by 2050, which equates to nearly 2.5 billion additional citizens living in urban areas [1]. These developments continue the longstanding trend of expanding urban environments, which are growing at three times the rate of rural centres. Urbanisation is associated with economic growth, as cities provide greater opportunities for trade and specialisation. Despite its potential to overcome distance, digital technology is accelerating this trend, with skilled employment and economic growth increasingly concentrated in a small number of large cities [2, 3].

Urbanisation will also create or contribute to significant challenges. Cities are an exercise in coordination, which becomes increasingly challenging with scale; congestion is one manifestation of inadequate coordination. While some aspects of cities such as their cultural rhythm are self-organising, other aspects are clearly not. For example, traffic management requires significant planning, as does disaster response. Furthermore, many cities have evolved alongside ports or waterways, reflecting their historical path to prosperity. However, these once supportive geographies may now leave these cities vulnerable to climate change and extreme weather events.

A key premise of smart cities is to leverage the increasing amounts of data being generated by cities to address these planning and management challenges. Data is generated by an array of sensors, from surveillance cameras through to climate sensors, operated by the public and private sectors. Further data is generated by devices carried by individuals (e.g. smartphones) and from their vehicles. Collectively this ‘Internet of Things’ (IoT) promises to solve many problems, ranging from the life-saving (e.g. vehicle sensors alerting emergency services to an accident) to the prosaic (e.g. smart fridges autonomously re-ordering milk). Underpinning these transformations is the idea that ‘data is the new oil’, an analogy which perhaps goes further than originally intended, as while a small number of companies have become rich from data, for others it can be a toxic liability if poorly managed.

Smart cities are not just technical, however, and there are different meanings or stories attached to this idea. For example, research on smart cities is often clustered around three distinct themes [4]: (i) smart technologies and their instrumental impact on urban life (such as the application of big data to the smart city, as described by Al Nuaimi et al. [5]); (ii) smart people and the increases in human capital and resources that technologies create in urban environments (for instance, Pramanik and Lau [6] describe the potential for big data in the smart city to improve health care outcomes); and (iii) changes in governance structures and practices, and evolving relationships in collaboration, innovation and stakeholder connection. Therefore, in some ways it is incorrect to think of the smart city as a singular, universal or uniform phenomenon. Instead, the smart city represents a diversity of practices, technologies and visions that come together in urban contexts. ‘Smart city’ means and symbolises different things depending on the point of views of technology corporations, urban officials, urban businesses and urbanites.

Different examples of and stories about the smart city highlight this, with some emphasising the economic [7], cultural [8], political [9, 10] and environmental opportunities [11] that the smart city might unlock as a socio-technical infrastructure. Narratives based on smart city cases studies are particularly prevalent among technology vendors who provide and sell technical offerings in this area [12], and perhaps reflect the vested interest these providers have in this space.

2.1 Platforms

Platforms are a critical element of smart cities as they enable multiple sources and types of data to be assembled for access and use by a range of stakeholders. With the increasing volume, velocity and variety of data (i.e. Big Data), platforms play an increasingly pivotal role in aiding the transformation of disparate data into information and insights that enable action.

As with smart cities, definitions of platforms vary. From a technical perspective, a platform can be defined as ‘a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components’ [13]. Digital platforms, which underpin smart cities, are a subset of platforms...
and can be defined as a ‘software-based product or service that serves as a foundation on which outside parties can build complementary products or services’[14]. This definition highlights third-party value generation and implies a separation of core functionality from the mechanisms that add value in the supply chain.

It is worth noting the distinction between technology platforms and market-oriented platforms [15]. The former provides an environment that enables third parties to develop software that is discrete yet has interoperable software tools and components. Software development environments and kits are an example of this. Market-oriented platforms, such as eBay, Uber or Facebook, enable and mediate the exchange of real or digital goods / services between those providing the goods and services and those seeking them. In this context, the Apple App Store and Google Play application ecosystems could be considered to be a fusing of technology and market platforms. The relationship between platforms and markets is considered in more detail below.

The role of data on platforms is important. Although all digital platforms run on and use data, for certain types of platforms, data is the primary value exchange. Examples include social media platforms such as Facebook, which enable the exchange of data about people and their lives, or open government data repositories that enable users to find and use open government data. Other types of platforms are enabled by data (e.g. online exchanges or sharing economies such as eBay or Uber). Transactions on platforms create data, and in many cases this data may have value and could be monetised.

Given the role interactions between many different stakeholders to create and maintain a healthy platform ecosystem (whether market or tech oriented), the governance of platforms is important. A range of external and internal factors need to be considered in the design of governance arrangements [16] including, for example, the degree of regulation of the industry in which the platform operates and the platform’s strategy and maturity. Common characteristics of platforms considered to be important are:

- **Separation** – Different elements of a platform (such as the underlying technology, organisation structure and business model) are functionally separated between the **core** essential elements and the **peripheral** elements, such as applications [17] [16]. This separation is a defining characteristic of platforms and informs how the platform operates (e.g. governance and business models).

- **At least two sets of stakeholders in value exchange** – From an economic perspective, platforms enable two different actors who would otherwise not be able to find each other, to connect and conduct an exchange. This is a two-sided market (providers and consumers of goods or services). A multi-sided market may exist where more than two sets of stakeholders interact (e.g. a value-added service provider).

- **Presence of complementors and third-party interactions that create value** – For some, a true platform requires the interaction of at least three sets of stakeholders: the platform provider, users and the value-added service providers that service users’ needs – referred to as complementors. Building on the notion of separation of core and peripheral elements, the separation between platform operators and complementors is an important characteristic of platforms, with operators providing the enabling mechanism for third-party complementors (e.g. application developers providing value, adding services to users). With the presence of complementors, platforms may be multi-sided markets depending on how many third-party complementors engage with the platform.

- **Potential requirement of users to provide data to the platform** – One of the defining characteristics of platforms is the need for data. Many platforms require data from or about users; for example, information about a seller and products being offered on eBay. For some platforms, the data about users and, potentially, transactions can be monetised.

The next section discusses the related notion of data markets – data and service exchange mechanisms that are enabled by platforms – and the emergence of data markets around data directly or indirectly provided by users as a function of interacting with a platform.
2.2 Data markets

Conceptually and practically, market mechanisms underpin the operation of digital platforms. In the context of smart cities, market mechanisms provide a critical lens to enable analysis and understanding of stakeholders, their incentives and the mechanisms that underpin exchange of value around data. The mechanisms and some of the nuances of the role of data in these markets need to be understood to support efforts that capture, collate, assemble and enable access to data by those who are best placed to use them.

Data underpins all markets and enables value exchange by providing information, such as the price and location a product or service being offered. This information provided by the third-party offering a product or service can be discovered and used by potential consumers. Many marketplaces are digital and exist online, enabling value exchanges that would not be possible in a physical market. Examples of these digital marketplaces include eBay, Airbnb and Uber. Market transactions generate data of potential value; for example, in understanding where passengers are looking for transportation and the key intensities of peak urban congestion.

A data market enables mutually beneficial exchange of data between those who have it and those who want it. Data markets exist across different scales and scopes, ranging from the one-to-one exchange of a single data stream or collection, to the many-to-many exchange of multiple streams and collections of data enabled by large integration platforms. The term ‘data market’ does not imply a financial transaction; therefore, open data repositories are a form of data market.

In a pure form of data market, data is the primary value exchange. Examples include Data Republic, Strava and more nuanced forms such as social media platforms, where information about users’ activities are publicly shared. As discussed previously, markets for the exchange of goods and services use provider data and generate transactional data. This data, were it to grow to sufficient scale, can become valuable and can be monetised by the operator of the market and/or platform.

Value chains exist in, and are enabled by, data markets with value-added providers offering services to end users.

The form and function of a data market can be described by the interaction of three factors:

- **Institutional arrangements** – Formal rules, social norms and the necessary compliance mechanisms. Clearly defined institutional arrangements are crucial to the efficient function of data markets; for example, they could underpin trust by delineating the agreed limits on the third-party reuse of contributed data. Included in institutional arrangements are the mechanisms by which data generators and data consumers effectively recognise the value (i.e. price) of contributed data. The challenge with a data market is in adopting exchange mechanisms that allow participants to effectively recognise and value contributed data, but also minimise the transaction costs of doing so. For many existing platforms, the price of contributed data is implicit in the data-as-payment model [18], which represents a kind of posted-price approach to exchange. In other cases, negotiated-price exchange mechanisms might be applied but these will involve high transaction costs that are unlikely to diminish with scale.

- **Information systems and flows** – Information lies at the heart of markets [19], providing the basis on which buyers can be matched with sellers and identifying mutually beneficial exchanges. However, poorly organised markets could exacerbate information asymmetries and lead to the disempowerment of one side of the market. As well as allocating resources in the short term, price signals are also important for guiding investment; for example, indicating to potential data contributors that participation is likely to be worthwhile, or to potential data buyers that they should seek alternative avenues. The exchange mechanism and associated institutional environment can facilitate or constrain this signalling. In the context of data markets this information includes metadata about the data and transactional data being exchanged about the data contributors and users.
• **Participants** – The data contributors, aggregators, users and their behaviours. The number of participants on either side of the market and their associated behaviours are critically important for market effectiveness. For example, thin markets (i.e. markets with few buyers and sellers) real goods are more likely to suffer from informational, operational and allocative inefficiencies, which diminish incentives for participation [20]. The effective thickness of a market may be increased in more ways than simply encouraging entry of more participants [21]. For example, an increase in the scope for participants to engage with each other because of a broader product offering within a market will enhance the likelihood of a beneficial exchange. Likewise, mechanisms that enhance trust among participants (i.e. privacy preserving technologies) will increase the effective thickness of a market.

Socially desirable markets can spontaneously result from the interactions of these factors, but by no means in every case. Market failure is a distinct possibility, particularly given the inherent socio-technical complexities in exchanging data. Understanding where and why markets fail provides a useful starting point to understanding the design of data markets and creating possible solutions. A likely source of failure in data markets relates to the ability of data consumers/aggregators to adequately inform participants of the intended use/reuse of their contributed data, and the related implications for participant privacy and perceptions of trust. This results in a lack of engagement with the market and an inability to create a critical mass of data, users and transactions that permit network effects, where the value of something increases with the number of other users.

### 2.3 The ‘personal’ in platforms

While the IoT implies that much of the data involved in smart cities relates to objects, in practice, most data relates to personal information derived from the actions and movements of individuals. For example, data collected by smartphones and vehicles reveals an enormous amount of information about the individuals carrying and operating those devices, even if it collected autonomously (and perhaps without the user even being aware it is being gathered). Smart devices also reveal much about their owners (e.g. smart refrigerators that reveal details about diet, household, activity patterns, absences, etc.). This suggests that great care should be taken in gathering and sharing such data.

#### 2.3.1 Informed consent for citizens’ data

Participation in data sharing arrangements such as data markets or data platforms requires individuals to be fully informed about the relevant sharing decision context. In practice, individuals engaged in data sharing are often far from fully informed, frequently facing intangible, complex and largely ambiguous trade-offs [22, 23].

Assessing the possible trade-offs of data sharing can be very difficult for an individual. It can be direct; for example, uncomfortable personal details, habits and proclivities of an individual are identified from data by others. Indirectly, a financial institution could hypothetically charge a higher interest rate based on an individual’s digital personality profile. Users of data-as-payment services, relying on ‘notice and choice’ permissions, are unlikely to be fully informed about the scale of costs involved in trading their data and privacy in exchange for ‘free’ access [18, 24]. Data sharing by large groups can also be associated with negative externality costs, whereby an individual’s resistance to data sharing is viewed negatively by the broader group [25]. While seemingly costly commitments to share data may be a legitimate response by individuals to signal desirable qualities [26] (i.e. membership of the low-risk group to an insurer), they can create socially undesirable costs to those who are unable or unwilling to share data.

Consider an individual presented with an opportunity to knowingly share their mobility data in exchange for a service (i.e. mapping/navigation services on contributed mobility data). To make an informed sharing decision, this individual must assess the scale of the respective benefits and costs of sharing data. The scale of benefits may be relatively obvious, in the form of the value returned by the service; however, costs are far from obvious. Costs may arise from the use of shared data for seemingly unrelated purposes by the service provider or by unknown third parties. The costs that arise through such use are likely to be very difficult to observe, and they could apply at any time in the future. In short, the individual cannot be informed about
the scale of costs. The consequence is that decisions over data sharing will be made inconsistently [23]; individuals are likely to make commitments to share data that are not in their best interests.

Inconsistencies in decision-making concerning data sharing are best illustrated through the variability of experimental results concerning the value individuals place on privacy. Experimental settings have identified positive values for privacy preservation [27, 28], zero or neutral values [29], and privacy values that decrease with social distance but increase with the number of potential recipients [30]. Importantly, values can change markedly over time with broader changes in context [31], and context (or perceptions of context) appears to be a key driver of behaviours and values in data sharing [22].

Under conditions of uncertainty, individuals appear to apply heuristics to make decisions about data sharing [23]; this may lead them to share data that they would otherwise not share. For example, an individual may rely on perceptions of an organisation’s reputation to overcome uncertainties about long-term costs of data sharing and strongly discount seemingly obvious costs. However, if the organisation seeks to use this data in a manner broadly at odds with initial perceptions (even if it is vaguely stated in the user agreement), then a strong sense of harm, distrust or betrayal could result. This suggests that while trusted organisations can emphasise their reputation to encourage the sharing of data, they must also work hard to maintain this trusted reputation.

2.4 Summary

Platforms underpin smart cities, enabling the integration of multiple streams of data, its aggregation and analysis, to deliver required information to city planners and service providers. Market mechanisms for data (and services on top of the data) are a critical economic perspective related to value exchange. These mechanisms may be explicit when the platforms are primarily exchanges for data, such as open data repositories; or they may be implicit, such as platforms where third-party contributors leverage value from the data generated, in ways that are often not evident to the data providers and users of the platform. Section 3 describes the landscape scan undertaken to explore smart cities, and the technologies, platforms and data markets being developed to support them.
3 Smart cities data platform landscape scan

3.1 Overview

A landscape scan was undertaken to explore the current state and nature of smart cities, and the platforms and data capture and exchange mechanism that underpin them. The primary objectives of the landscape scan were to:

• explore and document context and configurations of smart cities initiatives, and the technologies underpinning them
• explore the motivations for users/customers sharing or contributing their data to apps and platforms, and the mechanisms that provide equitable, trusted and well-governed access to collected and aggregated data
• distil insights and recommendations to inform both the development of a transport mobility application and the development of social and technical architecture for urban data platforms in general.

The landscape scan was undertaken as a desktop-based research and analysis task, exploring different examples of urban data platforms and related elements. It was not intended to be comprehensive but to provide a cross-section of extant initiatives in this space.

3.2 Methods

3.2.1 Defining the scope of the scan

An enormous number of platforms, applications, IoT devices, and smart cities solutions and initiatives that imply, or are based on, the proposition of building an urban data market were investigated. Given the breadth of the smart cities and urban data markets space, a targeted search strategy was used to explore the range of potential contexts in which urban data markets might be emerging. To identify case studies of interest, three inclusion criteria were initially developed for the scan. These criteria were deliberately broad to ensure that relevant initiatives beyond urban mobility (or even beyond what might strictly be urban or smart city domains) could be explored. The criteria for the scan were:

• Data platforms and/or market-like – Case studies should be platforms rather than applications. Platforms were preferred, as individual applications have a limited scope, and do not necessarily aim to create data aggregations that can be reused (i.e. have no data market aspirations). As such, they typically do not exhibit or engage with the complexity of data aggregation, reuse, value creation and equity issues in the same way that platforms, and the data markets they enable, do. However, those applications associated or integrated with platforms and applications that have an intent similar to that of a platform were included in the landscape scan.

• Urban focus – Case studies should be related to cities and/or elements of urban life. Some case studies were not primarily focused on urban areas or issues, but those that might contribute to an improved understanding of urbanism or of the nature of collaborative data were included (e.g. birdwatching platforms, which are ostensibly about birds but reveal how (mostly urban-based) birders explore their surroundings and share data).

• Data as primary value exchange – The scan aimed to explore cases in which data was the primary commodity being exchanged. However, examples of data as a by-product of exchange of real goods, such as taxi rides (Uber), public transport (NSW Opal travel card) or peer-to-peer house rental (Airbnb), were of relevance as they generated data that could be used to inform urban decision-making.

While undertaking the scan, significant latitude was given to assess cases that did not necessarily meet all these criteria if they had the potential to yield interesting and relevant insights around user contributed data or data market development.
3.2.2 Assessment approach

The assessment process comprised two steps:

1. Using the three criteria, a desktop review of documents, websites and other available sources was conducted in which the project team searched for urban data market examples and for platforms in the context of smart cities.

2. If an example met the criteria, a desktop assessment was performed using the framework described in Table 1.

The assessment results were analysed and synthesised by the project team (see Section 3.2.5). Examples of smart cities as a whole (either described in literature or in the news) were important objects of the search landscape, as it is within these initiatives that efforts to collect, aggregate, integrate and use urban data – effectively creating data markets – were assumed to be most concentrated.

3.2.3 Landscape scan assessment tool

To provide a consistent means of describing and assessing the dimensions and properties of the case studies, a customised assessment tool (or analytical framework) was developed.

Platforms (and apps with platform or data market-like configurations or aspirations) were selected as the primary object of the assessment. The rationale for this was twofold. Firstly, platforms and apps tend to be most identifiable and prominently featured examples in popular discourse. For example, applications are available through large, public application stores and ecosystems (e.g. Google Play store). Secondly, in many instances, emerging and potential data markets of interest are implicitly operating on a platform or through an application. Targeting applications, therefore, also targets platforms and data markets.

The analytical framework comprised three interrelated architectural viewpoints: social, technical and informational. This framework is based on an IT industry architecture standard called the Reference Model for Open Distributed Processing (RM-ODP) [32], which specifies five viewpoints: Enterprise, Information, Computational, Engineering and Technology. These viewpoints were collapsed into three architectural viewpoints: social (Enterprise viewpoint), technical (Computational, Engineering and Technology viewpoints) and informational (Information viewpoint).

The social architecture perspective was further subdivided into three dimensions highlighting the social (cultural and social practice aspects – including values, norms and ethics), institutional (governance, decision structures and rights, and other institutional elements) and economic (incentives, value drivers, business model, etc.). The focus on these social architecture concerns in the landscape scan reflects the knowledge gaps for smart cities identified in the literature including, for example, those related to economic sustainability and commercial success, issues around privacy and ethics of data use [33, 34], as well as the governance of smart cities and how these entities, in turn, govern people [35].

The social, technical and informational viewpoints were used to structure the assessment framework (Table 1). Elements used to characterise and assess platforms, drawn from conceptual models identified in the literature, were then slotted into the framework. Specific questions were developed for each element to assist team members in capturing and assessing case studies. The models from which elements were sourced, and whether the criteria were adopted, adapted or invented for the landscape scan, are briefly described below.
Table 1 Framework for assessment of smart city data market platforms

<table>
<thead>
<tr>
<th>Architectural viewpoint</th>
<th>Dimension</th>
<th>Element</th>
<th>Source (adopt, adapt, or invent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Social</td>
<td>Motivations for providing data</td>
<td>Invented</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Data providing users’ relationship with platform and its operators</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scale and extent of providers and users</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stakeholder engagement</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ownership (drivers) of the initiative</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Economic</td>
<td>Business model</td>
<td>Adapted – Plantin, Lagoze [17], Langley and Leyshon [36], and Lee, Zhu [16]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Incentives for engaging with the platform sharing data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical</td>
<td>Core and periphery</td>
<td>Adopted – Lee, Zhu [16]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Core components</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Peripheral (application components)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Functions provided by each</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Channels for data capture</td>
<td>Sensors</td>
<td>Adapted – IoT and smart city literature</td>
</tr>
<tr>
<td></td>
<td>Sources of data</td>
<td>Where does the data come from</td>
<td>Invented</td>
</tr>
<tr>
<td></td>
<td>Theme of data</td>
<td>Smart city domains addressed by the case study</td>
<td>Adapted – IoT and smart city literature</td>
</tr>
<tr>
<td></td>
<td>Scale and scope of data (and users)</td>
<td>Global, national, city, sub-city</td>
<td>Invented</td>
</tr>
<tr>
<td></td>
<td>Data as primary value exchange or by-product</td>
<td>Data</td>
<td>Adapted – Schreieck, Wiesche [15] and Lee, Zhu [16]</td>
</tr>
</tbody>
</table>

3.2.4 Assessment results

The web-based desktop assessment yielded 109 unique cases that were identified and analysed. The list of assessed cases is in Appendix A.

3.2.5 Synthesis and analysis of results

Data was analysed and synthesised during a series of workshops, identifying key themes and patterns present across the dataset, including points of commonality and divergence. The key themes helped the project team to understand and organise the results, which provided a broader perspective of the key drivers, arrangements and implications of contemporary urban data markets. These results are presented in Section 4.

3.2.6 Limitations and constraints

There were limitations and constraints to the landscape scan, which must be considered when interpreting the quality and integrity of the results.

- By using a desktop analysis and focusing only on those materials easily discoverable and accessible to the project team (web accessible resources), the scope and depth of information collected has limits.
● Publicly available information does not automatically reveal the true nature of the case studies analysed, making it difficult to draw an in-depth understanding of the more nuanced social, institutional, and economic issues and implications.

● Publicly available materials may reflect certain biases that limit deeper critical understanding of case studies. Significant amounts of material provide marketing, advertising and vendor case studies of applications and platforms. Certain assumptions and biases are likely to have gone into the stylisation and presentation of this material.

● While the theoretical framework used for the assessment was grounded in research, some categories deemed important during the design phase were found to be unimportant or impractical to use. These categories were dropped from the assessment and are not described here. For example, analysis of data as a boundary object was difficult to assess without a deeper engagement with, and understanding of, an initiative. It is anticipated that themes of interest that could not be practicably assessed through desktop analysis will be explored in more depth in follow-up research activities.
4 Findings from the landscape scan

4.1 Overview

There is no lack of smart city projects, platforms, initiatives and products. The landscape scan assessed 109 cases, ranging from smart urban initiatives at national, city or neighbourhood scale; to technology vendor and public sector platforms, and data market-like offerings (such as Huawei Smart City and London Data Repository); to specific applications spanning across several decades, scattered across Europe, North America, Asia and Australia. Although the scan makes no claim to be exhaustive, it showcases the tremendous diversity of smart city activities in today’s digital societies.

The landscape scan revealed a range of data domains (economic, energy, environment, transport, health, safety and security) and a spectrum of architectures, levels of integration and ownership. Of the case studies explored, 39 clearly relied on or engaged with travel or mobility data, 25 cases did not and 45 cases were indeterminant. For example, a smart cities platform offering such as Bosch’s will likely support transport data but this cannot be confirmed. Many more cases could be included; however, they are likely to confirm what has already been observed by the project team.

The landscape scan identified six salient dimensions of smart city initiatives, platforms and data market development activity:

- **geography** of the project or platforms (Asia, North America, etc.)
- **archetype** of data market relationality (app vs data repository vs platform, etc.)
- **place-based** city versus other geographic scopes (national, neighbourhood, etc.)
- **sector** of operation (market/industry, government, civil society)
- **vertical integration** of architecture (platform, platform + sensor, etc.)
- **horizontal domain integration** (horizontal integration) of data (energy, mobility, security, environment, health, etc.).

These dimensions of **geography, archetype, place-based, sector, vertical integration and horizontal integration** can be regarded as the ‘where’, ‘who’, ‘what’, ‘when’ and ‘why’ of the landscape. As reported below, these dimensions were used to distinguish the trajectories, tendencies and tensions affecting any attempt to create or sustain urban data markets. In other words, they are not just analytic categories but operational signals.

4.2 Smart cities – place-based technology configurations

To conceptualise the relationship between smart cities, the technologies in use, the platforms/apps/data products and data in circulation, and the different functions and domains of smart cities, the landscape scan adopted the conceptual framework described in Figure 3. The top of the diagram lists exemplar placed-based smart city initiatives. Below these initiatives are the various elements that can be configured to deliver a smart city vision. Three key types of actors that dominate and pervade the smart cities context – citizens, industry (primarily technology providers) and government – are listed below the exemplar smart city initiatives. The ‘Smart City Domains’ icons (right side of the graphic) articulates the key application areas in which smart city activities are focused, such as health care and economic growth. On the left-hand side, ‘Functions’ lists the data functions performed by data systems in smart cities (data collection, storage, processing, etc.). The functions are arranged to match the different levels at which these features are seen: access and visualisation are often linked to apps that return data to stakeholders; integration and analysis are features of the platform; while data collection and device management are associated with smartphones, sensors and interaction points with government systems through which citizen data is collected. The lines from citizens, industry and government to data collection mechanism indicate use by stakeholder groups of that particular channel to capture data. For example, governments collect data from citizens through service delivery (e.g. tax of rates) via sensors and applications. Data flows down through the centre of the diagram, from providers and to users, enabled by apps and platforms. This diagram is not hierarchical nor suggestive of importance. Instead, it is structured to visualise the way platforms, and the data markets developed on
them, operate and the domains they intersect with, to assist in framing the results of the analysis presented below.

![Conceptual model of the landscape scan](image)

### 4.3 Geography of smart city projects and technology offerings

While many prominent cases are located in Europe or North America, cities around the world are pursuing smart city projects. Cities in India, China and South America offer many examples, albeit less high-profile than London, Copenhagen or Toronto. Smart city projects located in different geographies and cultures often possess very divergent socioeconomic and regulatory flavours – even if they share the same technical elements (smartphones, sensors, servers, databases, data centres). For example, the Songdo Smart City in South Korea embodies different visions of urban life to the Montreal Mobility Data Hub.

#### Table 2 Geography of case studies

<table>
<thead>
<tr>
<th>Geography</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>39</td>
</tr>
<tr>
<td>North America</td>
<td>27</td>
</tr>
<tr>
<td>Europe</td>
<td>22</td>
</tr>
<tr>
<td>Australia – New Zealand</td>
<td>12</td>
</tr>
<tr>
<td>Asia</td>
<td>8</td>
</tr>
<tr>
<td>Unclear/Unknown</td>
<td>1</td>
</tr>
</tbody>
</table>

Of the cases explored, 30% have a global scope and are not tied to any particular city. These cases represent smart city technologies and capabilities from multinational technology vendors or other service offerings that could be used anywhere. Examples range from Uber to Pokémon Go to the Huawei Smart City platform. The technology archetypes used to support smart cities are described in more detail in Section 4.4. The remaining 70% of cases were associated with specific cities or were nationally scoped platforms or applications (e.g. the NSW TripView public transport planning app).

The cases were scrutinised in terms of their geographic scale and extent. The categories in Table 3 capture some of the almost fractal dimensionalities of smart city and urban data platform/market initiatives. They range from individual dwellings to multinational cloud-based platforms running on a global network of data centres.
Of the total cases, 22 related to specific cities (e.g. Kansas Smart City, Switching on Darwin, Sounds of New York City, Sydney Coordinated Adaptive Transport System), 25 spanned multiple cities or regions (e.g. India’s smart cities mission, the MUV app, Australian Urban Research Infrastructure Network (AURIN) or Spacer), and 34 represented global technologies specifically for smart city platforms (see products from Bosch, CISCO, Huawei, Microsoft, Siemens and Texas Instruments) or platforms that have global reach (Uber, Airbnb). Eighteen cases were combined projects or technology offerings, where either a country had a specific smart city policy in effect or was rolling out a national technology; an example of this in the Australian context is Telstra, a company who provide a national telecommunications network and smart cities solution. The neighbourhood cases relate to urban initiatives within a specific city, whereas the home cases relate to IoT technology providers with offerings in the domestic market (e.g. Google Nest).

4.4 Smart cities ecosystem

4.4.1 What ‘species’ inhabit this ecosystem?

The project team initially classified all cases from the standpoint of someone using or engaging with them. They considered the nature of the functions they perform and then placed them into four functionally oriented archetypes (Table 4):

- **Applications (apps)** are software typically on a smartphone or other mobile device, which provide specific services to a user such as a venue check-in and recommendations offered by Foursquare, or entertainment such as Pokémon Go.
- **Repositories** enable sharing or exchanging of information, providing a place to store and retrieve data. They are typically the many city data stores and exchanges, such as London Data Store or AURIN, a repository for Australian urban research data.
- **Platforms** enable more sophisticated multi-stakeholder (and multi-sided) interactions to collate, aggregate, integrate and use multiple streams of data (e.g. the Barcelona Digital City Initiative).
- **Others** are entities that contribute to smart cities but whose exact nature did not easily fall into the above categories. For example, technology manufacturer Texas Instruments makes vital sensor components for smart cities, but we were unable to understand the depth and exact nature of their contribution and involvement to the smart cities domain within the landscape scan.

Roughly equal numbers of these different species were encountered in the assessment. The distinction between applications and platforms is not always clear. It is not immediately apparent if an application is standalone or part of a platform, and some applications have grown to a scale at which their backends are turning into platforms, with data markets emerging from them. In many cases, it is hard to determine if a smart cities technology offering is in fact a platform (i.e. allows third-party complementors to interact and add/share/extract value), rather than being a monolithic system controlled by a single organisation.
4.4.2 The changing smart cities ecosystem

The cases indicated that the ecology of the smart city landscape has changed over time. Cases that have been around longer tend to involve apps and repositories. Repositories (e.g. London Data Store, Chicago Data Collaborative) experienced growth around 2012 (in line with the growing Open Government and Open Data Movement), with the platform cases emerging after 2015 (Figure 4).

Smart city initiatives currently favour platforms as multi-level integrations of people and things (as well as the data about them). However, the foundation for platforms was prepared by the many city-based apps and public data repositories driven through the Open Government and Open Data agendas of the last decade.

The species (archetypes) mix in smart cities, 1995-2019

The architectural composition of smart city technologies is changing. Many of the earlier projects (2007–2011) channelled geolocation data into platforms and databases for specific purposes. The goals were to track the circulation of people and things in cities, whether it concerned their movements through the city

<table>
<thead>
<tr>
<th>Archetype</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>App</td>
<td>40</td>
</tr>
<tr>
<td>Repository</td>
<td>31</td>
</tr>
<tr>
<td>Platform</td>
<td>34</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 4 The changing ecology of the smart city landscape

The architectural composition of smart city technologies is changing. Many of the earlier projects (2007–2011) channelled geolocation data into platforms and databases for specific purposes. The goals were to track the circulation of people and things in cities, whether it concerned their movements through the city.
(RiderLog or FuelMap) or problems that were present in the city (Boston Street Bump, NoiseTube, Flu Near You). From 2012, platforms and data repositories became prevalent. For repositories, value is derived from aggregation and analysis of data to reveal activity or domain trends (e.g. Copenhagen City Data Exchange; sometimes across cities as ‘The Six City Strategy’, the Police Data Initiative, OpenStreeMap.org, etc.).

Although these changes could be understood as a paradigm shift, they also build upon and reify each other. For instance, apps that appear to have little to do with smart city initiatives appear in the landscape scan (e.g. social contact apps such as Tinder, Grindr or Nearify). They are categorised as cases where social mixing patterns in cities changed through a combination of geolocative data and social preference data.

4.5 User location data

More than 50% of cases have an explicit location element (i.e. the data they are concerned with are tagged with user location), whereas only five cases explicitly do not (Table 5). For the remaining 45 cases, it was not possible to determine if geolocation is a core feature. However, it is safe to assume that most data of use in an urban context would need to be geolocated and therefore the vast majority of data collection, integration and analysis technologies would have a geolocation element or capacity.

Social apps (on smartphones) and their almost ubiquitous ability to provide information about users’ activities in time and space are of particular interest. These apps deeply affect city life and create an ethos in which data-mediated interactions become normal. The data generated through these apps is also of enormous potential value for those trying to understand patterns of interactions and service provision in cities – particularly in the context of mobility/transport data. Though individual apps are disconnected and often divergent, they prepare the way for the rise of the platform archetype, which is thirsty for sensor feeds and app-derived data.

<table>
<thead>
<tr>
<th>Spatial</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>59</td>
</tr>
<tr>
<td>Not sure</td>
<td>45</td>
</tr>
<tr>
<td>No</td>
<td>5</td>
</tr>
</tbody>
</table>

4.6 Vertical and horizontal integration

4.6.1 Vertical integration of physical and digital value chains

The degree of vertical integration present in smart city technology emerged as an interesting theme. As shown in Figure 5, a single technology provider may offer platform, sensor, and physical infrastructure products and services. Combinations of all three levels were well represented (16 cases), but the predominant form was sensors and platform (54 cases), whereas platform only represented 29 cases (Table 6). A few sensor-only providers were explored, but physical infrastructure-only providers were not assessed as they did not represent a ‘smart’ or data driven technology.
In the last three years, platform architectures combining sensor data, data repositories, and existing physical infrastructures (energy, light, transport) and urban services have become more significant, often linked to cloud computing platforms (Microsoft Azure IoT; Deloitte City Synergy, or CISCO Kinetic for Cities).

### Verticality of smart city technology architectures

<table>
<thead>
<tr>
<th>Verticality of smart city technology</th>
<th>Count</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Platform only</td>
<td>29</td>
<td>AT&amp;T Data Flow, IBM Watson, Microsoft</td>
</tr>
<tr>
<td>B Sensors + Platform</td>
<td>54</td>
<td>CISCO Kinetic, Nokia Impact</td>
</tr>
<tr>
<td>C Physical Infrastructure + Sensors + Platform</td>
<td>16</td>
<td>Bosch, Huawei, Microsoft, Telstra</td>
</tr>
<tr>
<td>D Physical Infrastructure + Sensors</td>
<td>4</td>
<td>Smart fridges, air-conditioning</td>
</tr>
<tr>
<td>E Sensor-only</td>
<td>2</td>
<td>Analog Devices, Siemens Mindsphere, Philips</td>
</tr>
<tr>
<td>F Physical Infrastructure only</td>
<td>2</td>
<td>Not considered i.e. not ‘smart’</td>
</tr>
<tr>
<td>G Unknown/Unclear</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

### Horizontality and scaling

A key element of the smart city is the ability to draw on multiple sources of data to provide a holistic view of a city and its real-time and simulated performance. This might mean incorporating government data from sensors operated by public and private sector agencies, government administrative data and citizen-contributed data through commercial or community operated applications. Therefore, the landscape scan looked at the nature and breadth of the application domains within smart cities that were being addressed by specific cases.

A definition of smart city domains is used to classify the type of data targeted in each case and the degree to which a case covered more than one domain. The landscape scan shows cases distributed widely across the domains of economy, government, education, health, mobility, energy and security (Table 7). Many of the cases inhabit a single domain such as living & health or mobility (Philips HealthSuite, Montreal’s Integrated Local Food System or FixMyStreet for citizen-contributed street issue mapping). However, alongside the tendency to vertically integrate infrastructures and apps, smart city projects have tended to target and embrace a broader set of data domains.

Increased horizontal breadth of the domains covered by smart cities initiatives has strengthened in recent projects. The more recent projects spread horizontally in different ways, sometimes by providing technical infrastructure that can be used to integrate data from different domains using a variety of sensors. IoT-driven platforms such as Nokia Impact, Microsoft City Next or SideWalk Toronto are typical of this approach. In other cases, increasing the horizontal breadth of data is achieved by fostering connections between diverse social actors (Chicago Data Collaborative or the Singapore Smart Nation Initiative). Broadly, technology-driven horizontal integration is based around IoT integration, while smart cities initiatives from government take a more people-centred and networked integration approach.
Earlier smart city projects tended to anchor themselves in more narrowly defined application domains (transport, policing, health, etc.). In addition to the drive to vertically integrate platforms, sensors, and infrastructures, there is also an increase in horizontal integration to access and integrate a variety of sources of data. This has direct implications for the configuration of data markets as interactions between different parties increase.

### 4.7 Which sector drives smart cities?

The landscape scan uncovered different sectoral provenance for smart cities and urban platform/market initiatives and offerings. Smart city products and services for tech-industry represented 50% of the cases (Table 8). Government and publicly funded smart city initiatives such as Canada’s Smart Cities Challenge or the EU’s Partnership on Smart Cities and Communities tend to be more expansive, diverse and webbed into the currents of civil society, with typically highly visible and prominent partnerships with tech-industry (e.g. Copenhagen’s City Data Exchange is built and supported by Hitachi). The technology industry were found to lead most smart cities initiatives, with leadership from government and civil society lagging (see Table 8). While one sector seemed to lead the direction of projects, this does not exclude partnerships between multiple sectors, although no clear examples were found of a three-way partnership between the sectors, a deficit discussed in more detail in the conclusions of the report (see Section 6.2). Civil society led cases tended to be localised citizen science style applications to enable crowdsourced data to facilitate improved government service provision, or peer-to-peer sharing and community engagement applications.

### Table 8 Sectoral leadership of cases

<table>
<thead>
<tr>
<th>Sector</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech-Industry</td>
<td>54</td>
</tr>
<tr>
<td>Government</td>
<td>29</td>
</tr>
<tr>
<td>Civil society</td>
<td>26</td>
</tr>
</tbody>
</table>

### 4.8 Lifecycle stage and level of maturity – from app to data market

A data market maturity model [37] identified three stages of a data market lifecycle, as shown in Figure 6. Several cases showed a similar pattern, which highlights the importance of understanding the lifecycle stage and maturity of an app, a platform and even an app transforming into a platform. The first phase (‘**Priming the pumps**’) involves developing a data market or platform, where the challenge is to engage with users to encourage them to share their data. The second phase (‘**Growing the pot**’) is concerned with scaling data holdings by growing a particular kind of data (e.g. mobility data) or possibly adding other kinds of data (e.g. traffic data). As the pot grows and gains significant scale and a centre of gravity, it enters the third phase (‘**Joining the dots**’) in which it will attract other data markets that will connect to it or consume it.

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2 Entities were assessed against all six domains to explore horizontal integration, resulting in multiple examples being coded to each criterion. A grand total is therefore unhelpful here. Of the 109 examples explored, 56 examples were identified as covering more than one kind of domain, and a further 46 focused on a single domain, while 7 had no clear domain.
In the landscape scan, several interesting examples of this evolution were identified. Strava, which started as a fitness/lifestyle social app enabling users to upload and share data about their fitness activity. As the user base and pot of data grew, the reuse value of a particular kind of data from the app – bicycle ride data – became apparent. In response, Strava developed a separate data market platform offering – Interestingly termed, ‘Strava Metro’ – which sells access to analytic services and aggregates data about bike travel patterns – a rich resource for urban planners.

Another example is Airbnb, which collects data about properties for rent and their rental activity as part of its platform-based, peer-to-peer accommodation sharing business. As the size of the user base and volume of rental transactions data grew, this became of interest and value to a range of potential users. Airbnb, in the spirit of the sharing economy to which their business contributes, has created an open data market for the data – Inside Airbnb – that enables access to data in aggregate form.

Finally, Foursquare’s remarkable journey from social app to data market and then to networked data market over a 10-year period is an illustration of the entire lifecycle model. Foursquare is now a leading crowdsourced location data market used by more than 100,000 app developers and many significant platforms like Twitter and Airbnb, with millions of active users providing one billion tagged geolocations each month. For more information, see The Foresquare Story in Section 6.4 for reflections on data sharing.

4.9 On smart cities and citizens

The overall aims of the landscape scan were to (i) explore the existence and nature of urban data markets and platforms, and mobility applications with platform-like aspirations; and (ii) distil learnings that might inform the project and broader practice to realise smart city visions. Most smart city initiatives are primarily dialogues between cities and the marketplace, as cities engage private vendors for solutions. Data is approached in a reductionist way through this dialogue and treated as a technology of governance or as a revenue stream. Citizens are simplistically and one-dimensionally treated as providers of data; they are typically not involved in decisions about data sharing and reuse. The scan identified several notable smart city arrangements, all of which have a significant technological dimension but few social dimensions; issues such as the implications of data generation, and the meanings of data, are not developed. It is worth noting that many smart city initiatives are announced with some fanfare only to falter or stall, failing to deliver what is promised. This may in part reflect their technology-driven nature and a limited consideration of citizens’ perspectives.

Part of the problem lies with the question of how public and private entities generate value and benefit from the smart city. For governments and the not-for-profit sector, value of the smart city lies with providing public goods and services – such as health care, security and environmental sustainability – more efficiently and effectively. This requires the assistance of technical consultants or vendors (e.g. IBM, CISCO, Accenture or Bosch). The value and revenue model of the private sector differs from the public sector; this has raised questions about whether smart cities are actually a means to transfer crucial public services into the hands of private service providers [38] and reduce the responsibilities of government in favour of market solutions [39]. By relying on proprietary technologies, there is also a risk of technological lock-in and path dependency, with cities required to engage with companies in exclusive, long-term relationships. This reduces the
possibilities for competition and the options for the public sector and citizens but creates private value for corporations, creating a tension between the public and private sectors.

In cities where ‘smart’ initiatives have been undertaken, there is variable community reception, with no guarantee of success, innovation or improvement in the quality of life of citizens [40]. These tensions between private and public value also have implications in terms of reinforcing disparities based on demographic characteristics such as income and location [41, 42]. This is problematic, as one of the potential benefits of smart cities is greater collaboration between social groups. For example, some commentators discern a shift from top-down, vendor-backed visions of smart cities (referred to as ‘smart cities 1.0’), to ‘more collaborative models of smart city governance (‘smart cities 2.0’) that emphasise a role for city governments in the curation and management of data assets to support a city’s strategic priorities [43]. There is a key role for government at all levels to create the spaces and cultivate conducive environments for these new models of engagement that ensure equity and reconcile the sometimes-competing drivers of government, industry and civil society. This is a more hopeful vision of the smart city, which stands in contrast to the problems and uncertainties that they also hold.

Given data is intrinsic to the smart city, and that data is viewed by the private sector as ‘the new oil’, questions have also been raised about use of data – particularly where people are the subject of data in relation to accountability, security, privacy and oversight of data in the smart city. There are continuing concerns about how data is collected, stored, used and shared in the provision of services where opting out is impossible, viewed with suspicion by potential service providers or detrimental to a citizen’s quality of life and participation in social life [44], [45]. The use of data to imagine, plan, predict and finally respond to urban life is a powerful value proposition, but brings associated risks of further entrenching disparities and unfairly targeting or treating different groups of citizens. Therefore, there are lingering questions and tensions around who has access to and authority over the data, how is this data analysed and used and with what oversight, how is the data collected, and what rights and regulations are applied to this data. Specifically, how equitable can the smart city be, and what must be done to achieve this?

4.10 Smart cities in practice

The realisation of smart cities is challenging. It is wrought with questions pertaining to who ultimately benefits from the smart city. Kitchin [33] notes that the oft-cited examples of successful smart cities do not represent a coherent or clear development of smart cities but are ad hoc patchworks of public and private initiatives – each with different motives. A few notable examples in Asia appear to be heavily technologically driven and focused on building the smart city fabric in greenfield sites first and then adding in the people. These examples are Songdo Smart City in South Korea, a ‘ubiquitous city’ housing 100,000 people in video-linked apartments and sensor-lined streets, and Singapore’s Smart Nation initiatives. Singapore was the winner of the 2018 Smart City of the Year and has reached a level of technological development described as a ‘sandbox’, with energy, transport and other urban infrastructures providing enough data to support sweeping data analytic experimentation.

Civil society and market involvement in many of the state-driven smart city developments have been limited. While Songdo and Singapore pay close attention to problems of maintenance, communication and mobility in the city space, they frame these problems in terms of efficiency, productivity and governance rather than belonging or inclusion. Songdo, completed in 2015, has been described as a ‘ghost town’ [46], which suggests that its lived reality does not match its technological promise. Similarly, Singapore’s Smart Nation initiatives, although oriented towards problems of managing climate change and an ageing population, do not set out any positive vision of data citizenship. The degree to which civil society is included in these initiatives reflects the broader cultural, social, political and economic context within which smart cities are embedded.

Examples of partial successes, or promising smart city initiatives that engage civil society, include Toronto, Copenhagen and Barcelona. In Toronto, the civil society has responded in force to plans by Alphabet-owned Sidewalk Labs to incorporate IoT and cloud-based artificial intelligence (AI) technologies into their urban development projects. The absence of accountability and privacy measures, open market access, a clear business model, and a means of collaboration or competition has attracted a sophisticated civil society
response. As of August 2019, public debate over next steps in the project continues [47], demonstrating the interests of civil society in these projects.

In some smart city projects, technological, market and civil society interests blend. A clear vision combining society, markets and technology appears in Copenhagen’s City Data Exchange (CDE), where an explicitly experimental and collaborative process of development has been adopted in order to build communities of practice around the exchange. Data exchange platforms by themselves are useless without a community of actors interested in data exchange. At the conclusion of the first major phase of CDE, the project reported on what needs to be added to the technological vision and imagined a space for collaboration between different entities [48]. Whether this collaboration concerned selling, use of shared infrastructure or research was less important than the fact that relationships between companies, institutions and organisations could develop over time with the exchange. A platform for data exchange should therefore facilitate a space to allow common interests to surface between state, market and civil society.

The Barcelona Digital City initiative shows clearer evidence of citizen engagement. Alongside a strong IoT implementation, a notion of ‘technological sovereignty’ has been developed alongside the technology. Technological sovereignty refers to a notion that data from/about individuals and the public ultimately belongs to those entities, and thus it should not be solely captured as economic capital by market actors or as governmental capital by state agencies. In the case of Barcelona, which is the iconic capital of Catalonia and a place with a strong sense of regional identity and public culture, localised social and economic structures have greatly shaped efforts to ensure that citizens’ needs, civil rights and equity are key components of the smart city conceptualisation and implementation processes [49]. Interestingly, the smartification of Barcelona has been the outcome of a de-institutionalised process, which itself has been significantly influenced by the cultural history of place (especially the sense of being ethnically different from rival cities like Madrid) and a sense of commons. Given this orientation, several transnational corporations that have attempted to sell their socio-technical vision and smart infrastructure have been largely unsuccessful. Instead, de-centralised grassroots community cooperatives are being encouraged and incentivised to design and develop their own localised, customised and open-source forms of platform infrastructure and digital development [49]. These enterprises are very much oriented to the local context and have the connection between participatory, civil values and technological change at their hearts.

The next section focuses on key factors that accentuate the potential for unbalanced platforms and data markets to materialise and become dominant. The main factors are the economic models that underpin urban data markets and the promises of enhanced efficiencies in service delivery and governance from technology, mass surveillance and automation. The section also discusses a requirement to diversify and improve the existing configuration of smart city designs. This can be done by accentuating the social and ethical dimensions of urban data markets and ensuring that they cater not only to the market and the state, but also to the diverse needs and perspectives of urban users. While primarily an issue for technology designers/providers and the policymakers/ regulators; however, it is also an issue for the public, as it is their data being used and harvested. Finally, the perspectives and tensions of these stakeholders are explored.

### 4.11 Role of state, market and civil society in realising smart cities

#### 4.11.1 The need for equity in smart cities initiatives

There are significant challenges and concerns related to maximising the value of data – particularly data collected through the public (state), private (market or industry) and civil society about citizens and their activities – while maintaining safeguards around the data. This is borne out by developments in the broader data landscape, such as the introduction of increased citizen rights over their data through the EU General Data Protection Regulation [50]. For developments in Australia, this is mirrored by the creation of the Office of the National Data Commissioner, the implementation of a data sharing and release framework to increase the reuse of public data [51] and proposed legislation for ‘consumer data rights’ [52].

Smart cities need to understand resource provision and consumption throughout the city, as well as understand of how different groups of people experience, live in and shape our cities. Data about people is therefore of the utmost importance. Ensuring citizens are more than just a source of harvested data requires:
• balancing the needs of state, civil and commercial sectors
• establishing the Fairness, Accountability, Transparency and Ethics (FATE) of data use
• respecting the rights of citizens as providers and subjects of data, and minimising any disbenefits to citizens
• showing genuine attempts to truly inform users when seeking their consent to (re)use their data.

Achieving equitable outcomes in smart city initiatives rests on the ability to reconcile some of the tensions between state, market and civil sectors, such as those around the use of citizens’ data.

4.11.2 Value drivers

A key dimension of equity is balancing the differing value drivers and competing interests of different actors. A triad of sectors exists in smart cities: state (i.e. all levels of government), market (i.e. private sector) and civil society (i.e. citizens). Each has its own value drivers, contributing to the realisation of smarter and thus better cities.

Figure 7 State, market and civil value drivers

In the smart cities context these sectors have different value drivers, as shown in

Figure 7. The market (in smart cities), represented primarily by commercial technology product and service providers, looks to generate value through the collection and use of data. The state, through its smart cities and other efforts at national, city and local scales, seeks to improve urban life by governing through data – such as improving the collection, aggregation and use of data to make decisions. It also seeks to regulate and govern key aspects of the data landscape through institutional arrangements.
Civil society is a more complex and nuanced sphere. It is the sphere of social interaction that is situated between the market and the state, comprising the ‘intimate sphere (especially the family), the sphere of associations (especially voluntary associations), social movements and forms of public communication’ [53]. In the smart cities context digital technologies and data are transforming everyday life and interactions in civil society. Ensuring civic space is maintained and including citizens in decision-making about their futures are the main concerns of civil society.

4.11.3 Sectoral concerns

Figure 8 depicts some of the key issues and themes that emerged from the literature review and landscape scan for the three sectors.

**State sphere** – Concerns focused on the development of appropriate legislation and regulation to keep up with the pace of digital disruption, encompassing such things as policies and legislation related to privacy and data rights in the smart city. In addition, state actors are concerned with becoming more data driven and smarter in relation to the design and operation of cities. Within this space are concerns about aligning city governance with data governance and, more broadly, achieving more inclusive and participatory city governance.

**Market sphere** – Key concerns relate to business models for applications and platforms, and the ways in which data can be turned into a revenue stream. Several models exist for this. Firstly, users can pay for services through a subscription. Secondly, application and platform operators may be able to use a ‘clip the ticket’ approach, taking a proportion of the value of all transactions performed on a platform, as eBay does. Thirdly, users may be offered free services, the costs of which are covered by public funding (e.g. with industry funded by government to provide a service). Lastly, revenue streams can be created by selling the collated data, access to this data or insights based on the data. Advertising can also be used to facilitate revenue, where advertisers pay for access to certain kinds of users. The issue of data latency, or how ‘fresh’ data is, relates very directly to notions of value of data.

Underpinning, enabling and constraining these revenue generation options are data regulations set by the state, as well as by the social licence granted to industry by civil society – the primary providers and/or subjects of the data.

**Civil sphere** – Concerns around privacy, surveillance, agency and the inclusion of civil society in state decision-making have an impact on the granting of social licences, and data legislation and regulation. With the emergence of AI, concerns about Fairness, Accountability Transparency and Ethics (FATE) of the algorithms, particularly those charged with the automation of decision-making, are increasingly important.

At the intersection of these three sectors are core concerns that play an important role in determining the success (or otherwise) of smart cities initiatives. These concerns are based around the value of data and insights that flow from it; identifying those who benefit from data circulation; and the incentives different stakeholders have to participate in smart cities initiatives, given the value and benefit flows. Advertising is an interesting concern within this space, as it is perhaps the most important revenue stream for many apps and platforms. In this model the user is the product being sold to advertisers. Aside from the philosophical consideration of whether advertising is a beneficial service for users, commercial, political or social advertising and other kinds of targeting raise serious concerns around FATE and the impacts of AI and data on civil society.

The concerns of these three spheres often appear to be somewhat disconnected and distinct from deliberations about the technology and information flows themselves. Although in some cases dialogue around institutional arrangements, social issues and the concerns of citizens occur in the smart city space, these do not necessarily permeate the technological realm.
4.11.4 Key tensions between the sectors

Attempts to realise a smart city vision need to balance generating public (state) and private (industry) value from data and insights (Figure 9). The former strives to maximise the utility of data to understand, then shape, society and industry, whereas the latter typically strives to maximise shareholder value. The tension between these different models of data use typically plays out through the formulation of legislation and regulation; however, policymaking often lags behind the design and development of technological innovations – the recent Cambridge Analytical scandal being a noticeable case in point. From the smart city landscape scan, smart cities initiatives are at present primarily collaborations between the market and the state; these two sectors entities are best placed to realise the vision of, and also stand to gain the most value from, smart cities.

However, public and private objectives must be balanced while also maintaining appropriate safeguards that allow the functioning of a healthy democratic civil society. As observed earlier, data about peoples’ activities, interactions and movements through time and space are of significant value to both the state and the market. Thus, the civil sector – and the social relations and personal data flows constituting this sphere – is predominantly the object of datafication and commodification. It is also where the impacts of the state and the market(s) – both in terms of service provision and on encroachments on data rights and sovereignty – are staged and felt.
In addition to the value drivers and issues within each sector, there are significant intersections and tensions between the sectors. As evidenced through the landscape scan, the market and the state engage in a cooperative dynamic, which is typical for urban data markets. Data is perceived – first and foremost, as an economic good to be extracted from exposed individuals in their various guises as workers, consumers, carers and patients – and rendered into different types of value. The state needs the market to provide various technologies, platforms and services to generate data economies and the insights required to oversee and govern infrastructures, citizens and social processes.

Moreover, the state is one of the market’s key purchasers/clients of digital technology and data services. And yet, significant tensions also mediate these relationships. The state, for example, is tasked with legislating, licensing and regulating data economies, and protecting the civil sector from unnecessary or unjust surveillance or aggressive below-the-line marketing. This can sometimes mean defining and circumscribing the nature and dynamics of data markets and enforcing penalties for privacy breaches or discriminatory profiling practices. Similarly, the market also influences the state and drives regulation through disruption, determining the capacities and function of digital technology (i.e. what’s available on the market).

There are also significant tensions between the state and the civil sectors in urban data markets. Although in certain situations and contexts, citizens tolerate the state providing security and other services in exchange for reductions in privacy. Many technologies operating in the smart city subject citizens to increasing levels of dragnet surveillance/tracking. For instance, in Perth and Darwin, municipal authorities are now using facial recognition technology and other forms of video analytics to track the movements and smartphone activities of street users. Citizens have increasingly limited legal recourse to access data collected about them and challenge how their data is processed.

Urban data markets have the potential to enable further incursion into the private and intimate lives of citizens. However, this is not without controversy and conflict. Civil liberties groups such as Privacy International and Civil Liberties Australia, as well as grassroots community initiatives, are seeking to make the state more accountable for its actions. The same devices used to monitor citizens are inverted to...
scrutinise the actions of state officials, an obvious one being Copwatch[^3], where community members can ‘safely and legally’ record interactions with police via an app as a means to limit police misconduct.

Finally, there are also tensions between the civil sector and the market sector that relate to data rights and data profits. Many market operators (tech providers and business users) approach personal data flows as a commodity to be mined, refined, processed and manipulated. As such, these economic models reduce the social dimensions and impacts of data expropriation. They therefore forego any consideration that individuals might (i) have an attachment to their data or wish to exercise some kind of sovereign rights over the content of data (including where it goes and how it is used); and (ii) desire to be alerted or remunerated when/if it accrues value. Thus, there are tensions and politics here around data ownership and data profiteering, and around perspectives on data where businesses and technologists treat data in instrumentalised terms, rather than as a social entity that can be thought of as an extension of a person’s body or identity. These tensions are particularly strong in the use of surveillance technology such as CCTV.

Associated with this struggle is the notion of autonomy. Humanities and social science research has revealed the ways in which data markets typically take on an asymmetrical form, where the individual providing the data – through their online practices or engagement with some sensing infrastructure – is effectively dispossessed from it. This occurs in two ways: firstly, through the inability to maintain control over where data goes and how it is processed; and secondly, through the various value(s) personal data might accrue as it is aggregated, analysed and rendered into insight. Thus, in order to maximise the social good stemming from emerging models of the smart city, the public needs to be better educated about ‘data hygiene’ and be provided with more opportunities to contribute to, and exercise better control over, the mobility of their data. Mediating the struggle for the commodification of data that is an expression of identity is a key tension that can fundamentally undermine the balance and sustainability of urban data markets.

4.12 The economics of platforms

Platform companies create value by facilitating exchanges between consumers and producers of goods or services. The value and power of these companies is determined by the size of their user base and the volumes of data they hold. As demonstrated in the landscape scan, platform technology providers (among others) are attempting to vertically integrate data value chains. By capturing as many data flows as possible from smartphones, through to apps and platforms, significant value can be created about citizens and their lives in the city.

The power and influence of platform companies in the public sphere has grown rapidly in recent years, with the likes of Facebook, Amazon and Google increasingly dominating their respective domains of the digital economy. As mentioned earlier in this report, many more emergent and maturing platform companies are likely to assert their dominance in their respective domains in the future. Much thought has been applied to questions around the broader socioeconomic implications of this dominance (e.g. [54]), including the implications for competition in markets with which platform companies engage [55, 56].

As indicated in Section 2.1, a platform company is often composed of both the core and some portion (perhaps all) of the peripheral elements. For example, Amazon’s core is a digital retail platform, but it also controls a large portion of the platform’s periphery (i.e. publishing, television, film production, IT, manufacturing for retail, etc.). While Amazon’s market platform provides a site for third-party retailers to sell their goods, it also provides Amazon with an opportunity to compete with retailers by also selling goods and services. Controlling the platform infrastructure – and information flows – upon which their competitive retail rivals depend, places Amazon at a distinct competitive advantage[55].

Competitive conditions in markets are generally desirable because any one participant possesses limited power to influence outcomes (i.e. prices), and therefore has limited capacity to adversely affect the market benefits experienced by other participants. There are strong incentives for platform companies to seek to dominate the markets with which they engage because, ultimately, they are likely to enjoy substantial profits.

[^3]: see https://www.copwatch.org.au
The vast economies of scale that platform companies often possess in the provision of goods gives them the ability to increasingly outcompete and extinguish competition as they grow. When competition has been largely eliminated or suppressed, the ability to set prices in uncontested markets could allow platform companies to achieve super-profits. During the early phases of platform growth the consumers are likely to benefit broadly (i.e. low prices), whereas the dominance phase of a platform company will ultimately translate into increased power and higher prices in the absence of government intervention.

At first glance, the dominance of platform companies in markets is problematic, with powerful effects of economies of scale enabling a dominant company to extinguish competition. However, this power may be harnessed for social good by recognising and realising the economic benefits of scale economies, while also limiting the ability of a platform company to use them. Considering the elements of a platform company as both the core and periphery allows us to think about the implications of their structural separation. Why might this make sense? Firstly, platforms themselves strongly resemble public utilities, which suggests that their continued existence and ability to take advantage of scale economies is highly desirable. Secondly, there is no sound economic argument for allowing a private company to control both the platform’s core and substantial elements of its periphery.

In markets where substantial economies of scale exist, natural monopolies can emerge from initially competitive conditions by taking advantage of increasingly lower provision of goods costs to eliminate rivals. The emergence of a single provider in markets where genuine natural monopoly conditions exist may be economically desirable; the lowest cost provider becomes dominant, and the public may enjoy the lowest prices of those goods [57]. For the provision of platform services, natural monopoly-like conditions are likely to support the desirable emergence of a single provider.

However, natural monopoly conditions are highly unlikely to be associated with the kind of goods and services that platform companies use their platforms to distribute. Viewed as a public utility, Amazon’s Marketplace, separated from Amazon’s own retail ambitions, could provide a highly efficient environment in which to match consumers with retailers at lower cost than either physical or digital alternatives. This is strongly desirable from an economic perspective. There is no reason to believe that Amazon’s activities on the periphery of their platform (or any other major platform company) as a publisher, producer, manufacturer or retailer necessarily possess the elements of a natural monopoly. However, the true competitiveness of these activities is confounded with the competitive advantage conferred by their core platform. In effect, the core platform cross-subsidises their periphery operations at the expense of their competitors. This is strongly undesirable from an economic perspective, thus supporting the argument for the structural separation of a platform company’s core and its periphery [56].

Viewed as public utilities, the platforms operated by Google, Amazon, Facebook and others greatly reduce the costs of introducing and consummating the socially and economically meaningful interaction (i.e. retailers to consumers, within and between communities, etc.). Matchmaking functions of this type are a cornerstone of the digital economy. However, in the absence of competitors these natural monopolies will seek to maximise profits by increasing prices. Just as other public utilities (natural monopolies) are often managed by governments, either through regulation (i.e. price setting) or direct ownership, it will be necessary to do the same in the digital realm.

To achieve the greatest potential social and economic benefit, governments can and should regulate these influential platforms to ensure they generate socially acceptable private returns to their owners. Furthermore, there are some potentially significant opportunities for government to engage more directly in this space by considering platforms as public utilities and working with other stakeholders to deliver data markets operated as public utilities. Specific recommendations about this are provided in Section 6.4.
5 Recommendations for the project

5.1 Overview

The goal of this project is to explore the development of an application exploiting privacy preserving analytics that would enable the capture of valuable data about citizens’ mobility; this data could then be (re)used by the government transport sector to inform transport policy and service delivery. It was recognised at the outset that incentivising potential users to download and activate the app, which logs data about users’ movements, would be a significant issue. De-risking data sharing was addressed through a technological approach, which can keep personal data on an individual’s smartphone, and conducted aggregate analytic activities, without centralising the data.

To address this issue of incentives, it was postulated that a way of rewarding data providers might be established. Furthermore, if a critical mass of data was created, it may represent enough value to a potential user that the user would be prepared to ‘pay’ for access to, or insights derived from, the data. As the data is of potential value to transport service providers, a payment in the form of discounted public transport fares could be a viable method of users ‘paying’ providers for sharing the data. The following section provides some recommendations on the social, institutional and economic issues (Figure 10) that need to be factored into the design thinking around scaling up the pilot application. This section also contains discussion and alternative strategies for scaling up in the context of these issues.
5.2 Incentives to use the app

While the project team find the app highly compelling, attracting the attention of a broader user base represents the greatest likely challenge. Smartphone users have access to a million or more apps, so the competition for users’ attention is intense. It is therefore important to consider what is likely to motivate users to install, and continue to use, such an app. In psychological terms, motivations may be classified as intrinsic and extrinsic. Intrinsic motivations drive things that people do for personal reasons; for example, out of interest or because it aligns with their values. Extrinsic motivations are provided by others, including payments, incentives or regulations. While there is some overlap between these different sources of motivation, it can provide a useful framework for considering user motivations.

5.2.1 Intrinsic motivations

An increasing number of people care about digital privacy. Many people are also motivated to contribute to public goods, which can include information on urban mobility. The app can support these motivations by demonstrating how the data provided can contribute to beneficial social outcomes such as improved transport planning, while also showing that users are in control of their own data (emphasising autonomy and self-efficacy). The more data is contributed and shared, the greater the potential public good outcomes – the app should tally this data and relay it back to users. This might also prompt users to encourage their friends to contribute. While intrinsic motivations may not appear to represent ‘proper’ economic incentives, their power and importance should not be underestimated. In practice a great deal of what people do in the public sphere is due more to intrinsic rather than extrinsic motivations – from supporting charities to just behaving in a civilised manner.

Even in the potentially anonymous digital realm, intrinsically motivated actions are widespread; for example, Wikipedia, TripAdvisor and the many online question-and-answer sites offer no formal incentives for contributing information. Therefore, sharing data to support intrinsic motivations of public benefit should be the starting point, not the last resort. However, they are more difficult to understand and manage, and can be ‘crowded out’ by financial incentives [58].

5.2.2 Extrinsic motivations

Extrinsic motivations are more prosaic but can still be nuanced and multi-faceted. Most apps earn their users’ attention by being useful, by providing information or through entertainment. A mobility app could allow users to track their own journeys and perhaps compare alternative transport options (particularly if
comparing one user’s commute to another’s). However, many other apps already offer similar services and have more data from which to draw. The app might seek to offer reciprocal incentives. Users who contribute data might get access to others’ data (with privacy preserved). For example, users who have contributed sufficient data could be enabled to propose a question to be analysed from the data pool or pushed out to other users. Requiring some degree of active participation such as contributing data could avoid the problem faced by many crowdsourced sites, in which a (non-representative) minority contribute the data while most users just browse it (e.g. TripAdvisor, etc).

Given data has value, ideally an app would pay its users for providing data. While attractive in theory this is unlikely to work in practice, particularly for relatively low-value data such as personal mobility. The marginal value of any individual’s data is likely to be extremely low and would often be less than the transaction costs of arranging a payment. Tiny incentives would provide little motivation and can be counterproductive as they crowd out intrinsic motivations. Formal incentives can also establish formal power relationships, particularly as some will be inherently less able to contribute data than others. Another issue with individual payments for data is that the marginal value of data is likely to decline once a certain amount has been obtained, so those who initially sell data may diminish the value of subsequent contributions; they may also inadvertently reveal information about others, as their data are extrapolated to describe those with similar (e.g. demographic) characteristics [59]. Collective incentives may prove more effective, particularly if they can build on existing intrinsic motivations; for example, for every X bytes of data received a donation will be made to a particular charity. Such collective incentives can also go some way to disguise the low marginal value of individual contributions.

A related possibility would be for the app to establish sponsorship or marketing arrangements with third parties, who would provide various forms of incentives to users. For example, travel authorities may be willing to provide discounted fare to users who provide data. For others it could be a marketing or promotional opportunity; for example, coffee shops offering discounts. Some sponsors may wish to take this further, linking incentives to observed user behaviour; for example, someone who has used active modes of transport, or public transport, which can be verified through the app, may be provided with some form of reward. While incentivising desired behaviours is routinely done by policy makers, it should be approached with caution, particularly when associated with a powerful surveillance tool such as a mobility tracking app. Even if ostensibly entirely voluntary, there are scenarios in which users could be compelled to share their data to access a service or participate in an event.

5.3 Attitudes towards privacy and trust

People’s attitudes about privacy are changing from notions of secrecy to controlling information and maintaining dignity [60]. People are generally happy to share data to be used and shared if it is done in a way that maintains trust, enables transparency and retains the original purpose for which it was collected.

Privacy considerations and perceived trust can impact on people’s decisions to sign up (or continue) using a service or device. The service provider and the user’s perception of the trustworthiness of an entity offering a service that requires provision of personal data can play an important role here. A recent survey [61] found that while only 16% of Australians would avoid dealing with a government agency because of privacy concerns, 58% would avoid dealing with a private company. Health service providers were rated much more trustworthy (79%) than e-commerce (19%) or social media companies (12%), with financial institutions and government departments occupying a middle ground (59% and 58%, respectively). Personal characteristics such as a person’s age and the type of data people are asked to share also have a strong impact on the willingness or reluctance of data sharing. For example, 42% of people (especially those aged over 65) are reluctant to share financial information, 24% are reluctant to share their address, 14% their date of birth and 13% their phone number. With respect to the above-mentioned incentives for sharing data, 33% of Australians reported to trade personal information for rewards and benefits.

Although many people say that they care about their privacy, many continue to use services or buy devices that they say they do not trust. This is exemplified in a consumer report on smart speakers in the US [62], which revealed that even people who express privacy concerns still go ahead and buy such devices. Approximately 22% of smart speaker owners report to be very concerned about privacy issues and those
consumers who are very concerned about privacy are only 16% less likely to own a smart speaker. Potential reasons for this disconnect between people’s perceptions and actions are:

- People do not understand the nature or extent of data that is collected.
- Terms & conditions and privacy statements are too complex.
- Consumers believe they have no alternatives (most companies are acting in a similar way).
- People assume others / the government will take care of privacy. Eighty-eight percent of people believe that regulators should ensure privacy and security standards, 80% believe it is the service providers’ responsibility, 60% believe it is the consumer’s responsibility [63].
- People may actually not care that much about privacy.
- The trade-offs are worth it.

The last point refers to consumers trading off privacy concerns with the perceived value (incentives) they are receiving when using a service. This process has been discussed as a rational process in terms of a privacy-calculus model (people weigh the anticipated risks of sharing personal information against the potential benefits). However, such assessments have been shown to be bounded by people’s existing attitudes or dispositions (e.g. general privacy concerns or institutional trust), cognitive resources and heuristic thinking as well as affective states (i.e. people may underestimate privacy risks if a service elicits positive effects) [64].

Trust in a service or service provider can be built by giving people control over information, providing clarity about how the data is used and protected, assuring personal information is treated with care and by demonstrating competence (e.g. inform customers immediately if privacy problems arise). Trust in the context of data sharing can be affected in many ways. This includes trust in the system itself (system security, privacy, logistic aspects), relationship trust (trust in service provider and/or the service provided – e.g. some may not trust Google as the service provider but trust Google maps application to provide accurate information) or a service delivery (e.g. interface design, ease of use and service performance can impact on users’ trust perception). As with any type of trust, service providers must be aware that people’s trust is more easily lost than built. While a trustee’s objective properties – such as competence – or subjective properties – such as honesty – can help create trust [65], deception and misinformation can easily destroy it. Once a person has lost trust, it can take a long time for trust to be regained.

5.4 Scaling from app to data market

**Achieving critical (data and user) mass:** For many applications, particularly those that have a strong social sharing incentive around them (e.g. Facebook or Strava), becoming attractive to users requires a critical mass of users and data. Some applications may deliver value to a single user, and not rely on aggregation of other people’s data (e.g. Dropbox). However, from the perspective of an application business operator, critical mass needs to be achieved; otherwise, the business model is not viable. Of course, there are many diverse models of attention economics in operation that ensure users are both initially attracted to the application and continuously returning to it to experience pleasure, knowledge, feedback or convenience.

Data markets are emerging, though not necessarily under the purview of smart cities. These typically emerge from platforms that encourage users to submit their data as a part of use, thus generating significant data holdings, or as a by-product of some transaction enabled by the platform. If these data holdings reach critical mass due to the volume of data held, they become valuable in their own right as the data can be (re)used for other purposes (e.g. to understand patterns of building occupancy, tourism or citizen mobility). For example, both Airbnb and Strava are now offering access to the data generated on their platforms: building occupancy and rental business data through Inside Airbnb⁴ and mobility data through Strava Metro⁵. These data are being offered under both free and commercial terms and can be used to inform urban decision-making, such as housing and transportation planning policies.

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⁴ A complete description can be found at [http://insideairbnb.com/](http://insideairbnb.com/).
⁵ For more information, see [https://metro.strava.com/](https://metro.strava.com/).
The implications are that selective public and data scientists with the know-how and wherewithal can perform advanced analytics on the data to produce novel visualisations of urban markets and practices. These can then be used to inform public understanding about particular issues (such as local housing markets in the case of Inside Airbnb), and some of this aggregated data can be reclaimed and repurposed for the public and municipal good. This is, however, contingent upon the transparency and accountability of analytics and datasets.

**The Foursquare story:** Foursquare launched one of the first of location enabled check-in applications in 2009. The app used an innovative location layer and gamified check-ins, allowing users to compete for badges that provided them status in relation to the places they checked in to; for example, a user could become a ‘Mayor’ of a restaurant. Its novel use of location and gamification, and its timing as an early mobile social network, enabled it to grow the data pot quickly. By the end of its first year of operation it had half a million users, 1.4 million venues, and 15.5 million check-ins [66]. However, competition also came quickly with Yelp, Facebook and many others.

In 2014 Foursquare introduced some major innovations replacing the Foursquare app with Swarm, a more fully featured lifelogging and tracking tool that enables users to check-in and also to see nearby users. More interestingly, it created a city data market. Using check-in data that provides up-to-date information on 105 million places that its users were visiting, it created the Foursquare City Guide — a tool for local recommendations and discovery. Crowdsourced data continually collected through Swarm was fed into the market and, as of 2017, it has collected information on 1 billion place visits every month while its users have shared more than 600 million photos on the platform [67].

To continue to grow the pot, it turned its attention to venue owners, providing a platform for them to claim and manage their venue listings on the platform. It now has more than 2 million businesses with a listing on Foursquare. As the volume and value of its data grew, it developed a network of partnerships with other app developers to gather more data. Foursquare location data is now used by more than 150,000 developers worldwide and major platforms such as Uber, Airbnb, Apple and Twitter incorporate Foursquare location data into their apps as a point of interest layer, providing context for and enabling tagging of content provided by users of these apps. It has now even embedded itself within smartphones, with Samsung Galaxy phones natively using Foursquare data to tag the location of photos [68].

Though tough to replicate, there are elements of the Foursquare story that could be used to inform the growth of an application into a data market. Firstly, the initial incentives for use of the app were based on its utility, providing value to users, together with a gamification element and a strong social networking element. Secondly, the identification of venue owners as a potential customer for the platform, leveraging crowdsourced data provided about the venues by app users, incentivising venue owners to engage and claim their listings. Lastly, the approach used by Foursquare: interacting with and neutralising potential competitors by providing them access to their location-enabling capabilities and making them part of the network rather than direct competitors.

**5.5 Factoring social dimensions of (mobility) data into the design**

**Digital is social:** Social concerns need to be considered in every aspect of the project. Decisions at every stage of the project are made by people – people with particular social values and beliefs that can affect what they think, make and do. For applications that require people to subscribe, sign up and agree to having their activity recorded and data shared – noting that these are some of the most valuable kinds of data for smart cities – there is a need to navigate a complex set of challenges and design considerations.

**Appreciating app users’ perspectives on data:** Critical to the success of an equitable data market is an understanding of what data means and represents to the diverse groups of people generating this data. This demands that app or platform administrators conduct ongoing research and collaboration with users, and are sensitive and responsive to different models of value around data (such as security, privacy, trust, anonymity and accountability). This research should surpass reductionist economic and governmental paradigms that currently dominate this domain, and the evaluation and research measures used to legitimate these markets.
Appreciating these perspectives is critical in determining acceptable approaches to data handling, as is the need to utilise analytic approaches that operate at the edge (on a user’s device), and not require data to be shipped for analysis. The social licence around personal data, and what users consider to be acceptable, is dynamic and must be understood and factored into app design, together with the business strategies and end user licence agreements that establish contracts for data (re)use (see Section 5.7).

5.6 Development team composition and deepening user-centred design

**Multi-disciplinarity in software development teams**: The diversity, characteristics, views and representativeness of people making decisions reflect on the direction of projects. Although it is not always possible to achieve social diversity in any given team, it is critical that disciplinary diversity is reflected in a project team. To ensure a more holistic and adaptive product for this project, a team comprising technologists (with expertise in privacy, analytics, software development), business analysts, digital sociologists, economists, psychologists and experts in socio-technical systems has been assembled to explore these issues and to cross traditional disciplinary boundaries and divides.

**User-centred design**: Furthermore, user-centred design approaches are now recognised as best practice in any technology development activity. This requires that a range of stakeholders, including the end user, are actively engaged to co-design and test technical solutions that are built iteratively. It is essential that a user-centred design approach is adopted to ensure the voice of the user and their diversity of needs is heard, and to reflect these insights in design decisions.

5.7 Privacy stance

**Organisational rules and stance**: The development of any app takes place in an organisational context, and within broader jurisdictional context(s). These contexts impose rules, constraints and requirements around data practices and define the ‘decision space’ within which an application can be designed, built and operated.

An organisation’s stance around commercialisation and profit-seeking, and the business decisions it makes about how to potentially reuse and generate value from data, can greatly affect the design of an app. Implicit business models and assumptions about data reuse and value generation can be hardcoded into application design. The private sector has differing approaches to privacy and the openness of data ecosystems; for example, the different privacy stances that shape and inform Apple and Google business activities.

Although public sector treatment of citizens’ data is subject to significantly more rules than that of private sector, publicly funded research organisations such as CSIRO are uniquely placed to be able to explore new ways of thinking about, and engaging with, data in equitable and transparent ways. Privacy preserving analytic techniques that allow users to keep control of the data are examples of how new approaches could be used to capture and unlock new sources of data.

CSIRO is a trusted brand and that trust can be leveraged to achieve outcomes that might be more difficult for others to achieve. However, with the mantle of trust comes significant responsibility, and so it is important that the project continues to make strategic decisions about potential ways to reuse data while ensuring equity.

5.8 Informed consent and end user licence agreements

**From legalese to user ease**: Applications that collect user data present users with terms and conditions of use that are of significant length\(^6\) and complexity. Written by lawyers, the agreements often lay bare the complexity of the network of systems that may be sharing data, as they must disclose the nature of data exchange in the ecosystem. Users are expected to either accept or reject these terms and conditions which are, in some cases, almost impossible for a layperson to interpret and understand. From an ethical

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\(^6\) Microsoft’s Services Agreement runs to 16,000 words.
perspective, ensuring that users are aware of the ways in which the data will be used by the custodians of that data (i.e. the application developer) is critical to the informed consent of users.

Simpler statements about how data will be (re)used should be developed. The combination of simpler statements, education and awareness raising among users around privacy and data rights would assist in ensuring that consent is indeed informed.

The design of end user licence agreements, and the degree to which they encourage people to consider options, is worth considering. The wording within those agreements that encourage people to ‘click to accept’ can nudge people towards acceptance without considering options.

**Finer grained control over data sharing:** Providing more fine-grained control over data reuse may also be a useful approach, as not all data is of equal sensitivity. Rather than a single blanket statement, set by the application provider, it might be beneficial to offer users options associated with specific kinds of data in easy to read forms and at appropriate times in the digital workflows (rather than just on download and initiation of an app). The choice architecture for end user licence agreements are also important here. Adopting an ‘accept it or leave it’ approach may exclude certain users who may be willing to provide some but not all data and may contribute to attitudes of resignation among users who feel compelled to accept licence terms.
6 Recommendations for broader smart city practice

6.1 Overview

The intention of these recommendations is to inform those who are involved in the commissioning, designing and delivering of smart cities. Rather than present a prescriptive model we instead refer to several key factors that heighten the potential for one-sided or unbalanced urban data platforms to materialise. From these, we provide several recommendations to improve the configuration of smart cities.

We draw attention to the social dimensions of smart cities – the civil society and the local communities these initiatives affect – and the need for technology designers/providers and policymakers/regulators to deeply engage with citizens, as well as the issues related to data about or collected from people. Principally, this entails viewing data in a more holistic way – for example, as an extension of an individual and their civil identity – and opening opportunities for dialogue about equity between data providers and those who seek to use their data.

Most smart cities visions are based on the axiom that harvesting and analysing more data equates to increased efficiency and lower transaction costs to run cities. Governments seeking to build the physical and data infrastructure for smart cities partner with the commercial digital service providers to achieve this. These providers typically seek to capture and exploit the value in data for profit. However, those producing the lion’s share of the data – that is, citizens as they move, consume and transact – are for the most part ‘locked out’ of decisions about how their data is used and what value is generated from insights based on their analysis of the data. Indeed, most of the time, citizens and communities have little to no awareness of when their data is being harvested and used, by whom and for what kinds of outcomes.

These factors must be addressed to ensure the social licence to deliver smart cities is retained, and that ‘smart’ actually means ‘better’ for citizens and businesses. Three primary recommendations are provided that (as shown in Figure 11) aim to achieve equity by (i) adopting a multisectoral approach that treats civil society as key stakeholders in the configuration and operation of smart cities; (ii) establishing appropriate governance mechanisms that enable the participation of citizens and the collective – and transparent – governance of their data; and (iii) developing data platforms as public utilities that retain space for the generation of public value (e.g. through improved public transport), while providing sufficient space for industry to operate and generate private (i.e. shareholder) value.
6.2 A multisectoral approach with civil society as a first-class citizen

In order to facilitate urban data markets and smart cities structures that are more equitable and democratic in function and effect – and less shaped by the prevailing technocentric, surveillance driven and exploitative economic models – additional values that emphasise autonomy, collaboration, fairness, transparency, wellness, proportionality, reciprocity and accountability should be factored as complementary organising principles into all aspects of smart city design and operation. These values need to inform a range of aspects of smart city data market design and administration. These include the design of regulatory structures that adequately address data rights and sovereignty, the development of data literacy programs, and the inclusion of citizens’ representatives in decision-making and evaluative processes. Together, these approaches will allow citizens and communities to have more involvement and stake in data market structures, processes and practices. We recommend adopting stances that seek to better harmonise the economic values and rationalities currently driving these systems with social and ethical values that emphasise the need to treat data as more than just a naturally occurring raw material. Data is more than an emanation from social relations that can be harvested and rendered into currencies of power and revenue, and it should be treated as such.

We recommend that the civil sector be treated not as a passive object to be exploited and marketised through apps and platforms but, rather, is afforded greater representational agency and opportunities to collaborate in the co-design, co-development and continued operation and governance of smart cities.

It is critical that the various forms of wealth (be it economic capital or improved understanding of environmental dynamics, corporate taxation or local authority performance, etc.) generated through the digital transformation of cities is equitably distributed among all stakeholders, not just state and/or industry actors that own and oversee the means of data production and often ‘lock out’ alternatives. There are significant opportunities for citizens as users of data collected about them to make cities smarter and more liveable; for instance, in the use of smart meters to assist consumers to better manage their energy consumption.

Of course, this implies a need to conduct research on how diverse citizens and social groups regard, understand and engage with digital technologies, apps, platforms and urban data markets in their everyday lives, and how they would like them to perhaps be differently configured and regulated. The work of...
understanding what ‘better’ looks like for citizens, as well as for government and industry, is therefore an important mediation process, demanding more empirical research.

This recommendation also implies providing more publicly accessible information about how smart cities programs will work as complex socio-technical assemblages. For example, what protections and services they aim to afford, how their algorithms have been developed and will be regulated, and the likely implications and impacts these initiatives will have for civil rights and values – especially the right to the city and public space. Deep citizen-centred co-design will enable citizen engagement and ensure that smart does mean better for all.

Building equitable data markets that deserve public trust and retain a social licence to operate requires ongoing negotiation of informed consent between service users and providers. This goes beyond consent being a bureaucratic tick box exercise occurring at the commencement of a service, with terms presented in opaque and confusing ways. A shared understanding about what a better and more flourishing city looks like, and information about how a smart city program will work to support these objectives, are key ingredients to ensure the public legitimacy and approval of these activities.

It is also recommended that capacity building should be provided for those in the business of developing and organising platforms and components technology, to assist in the transition towards more holistic and contextually sensitive ways of treating data about citizens as a shared social entity and public good.

These recommendations require that state and community groups collaborate more around the meanings and implications of urban data markets and co-design a set of agile protective solutions that help address some of the surveillance excesses and data asymmetries found in existing models. These solutions also must review and, where necessary, strengthen accountability and enforcement measures (and financial and legal penalties) as they relate to the development and use of algorithms, data-based breaches, hacks and automated processes of discrimination.

Affording users more autonomy, and visibility into and rights over the creation and use of their data, is likely to increase levels of public confidence. This is a key outcome in a period where there have been many prominent local, national and global data scandals that have undermined individual and public trust in data economies. Obviously, all recommendations need to be balanced against ensuring the mutual profitability and sustainability of data platforms, and not unduly stifling the capacities of business sectors to innovate and unlock social value through data harvesting and processing. Institutional arrangements – particularly those around the governance of smart cities and data platforms – must reconcile these competing perspectives and, ideally, provide for community representation to shape the design process and to steer ongoing operating practices and cultures.

**6.3 Institutional arrangements for data platforms**

**6.3.1 Design of governance arrangements**

Institutional arrangements that guide and steer the design, implementation and operation of smart city data infrastructure are needed to ensure equity in data markets by respecting the diverse views and protecting the rights of citizens, while enabling space for realisation of public and private value. Institutional arrangements comprise the authority structures (or decision-making bodies) that enable collective agreement, and the rules and policies that they produce, that together steer (i.e. govern) collective activity. A range of institutional arrangements that span strategic to deep technical concerns around IT and data governance are typically needed for large complex projects.

Given the critical role of governance in achieving success in any collective initiative, it is surprising how little effort goes into the design of regulatory authority structures and processes of governance. Current approaches to governing complex systems and stakeholders are often trivially simple comprising boards, committees and working groups with lines of accountability and reporting between them. These virtual organisations bring key stakeholders into decision-making processes, enabling collaboration across organisations, and may be permanent in nature or time bound (e.g. created for the duration of a specific project). Project management methodologies incorporate well-articulated governance structures and
processes for project decision-making. For example, PRINCE2 (PRojects IN Controlled Environments)\(^7\) has on its project board representatives from senior suppliers (those delivering into the project), senior users (those benefiting from the project outputs), and the project owner. It also has well-defined process models, including those for the delegation of authority for decision-making. However, PRINCE2 is typically used for the delivery of time bound projects rather than for the long-term sustained operation of infrastructure capability. Longer term institutional arrangements, patterns and models of governance for data infrastructure tend to be ad hoc and tailored for the specific context.

In many models of governance, capital decides; that is, those providing or controlling funding for an activity have significant sway over decision-making. Furthermore, the degree of representation and stakeholder voice in decision-making is highly variable. Reference groups are often established to enable identified stakeholders to advise and provide input to decision-making bodies. However, these groups often have limited decision authority and therefore little power to influence decisions.

To address these challenges, it is recommended that the design of governance (to the extent possible) allocates decision rights more equitably to those who are affected by the decisions.

**Representation:** Is a key challenge in governance, and the degree of buy-in and commitment from stakeholders is influenced by the degree of representation and decision rights that stakeholders have in decision-making. Ensuring that the right stakeholders are represented in the design and administration of these systems (that is, which stakeholders should have a seat at the table) is an important consideration for ensuring an effective decision-making process, and also equity and fairness. The effectiveness of a representational role is determined by the degree to which any given representative in the decision-making process acts or speaks in the interest of the community (a collection of organisations or individuals) they are representing, rather than their personal interests or on behalf of a particular organisation. It is recommended that citizens are engaged and represented in all levels of decision-making within the smart city space. This could be achieved by identifying existing representative groups such as community groups or not-for-profit organisations to represent the interests of a broader set of stakeholders into operating frameworks.

**Decision rights:** The design of decision rights in decision-making bodies is critical. The two key kinds of rights are ‘decide’ and ‘advise’ (i.e. provide input to a decision made by someone else). Many collective decision-making bodies consist of those who will be significantly impacted by decisions, and those who will not. Ensuring that ‘decide’ rights are appropriately allocated based on the degree of ‘skin in the game’ is an important aspect of governance design. It is recommended that citizens are provided with appropriate level of decision authority, rather than simply being ‘engaged’ and ‘invited’ to contribute ideas. While engagement has been proven to improve citizens’ perception of government [69], long-term sustained success of smart cities requires deeper substantive citizen participation in decision-making.

Stakeholders, context, issues and needs change as initiatives mature. It is therefore recommended that agile and reflexive approaches to governance are adopted. This means that governance arrangements should not be dealt with in a ‘set and forget’ fashion but need to be continually reviewed and adjusted according to need. Furthermore, it is recommended that assessments of governance effectiveness be designed into institutional arrangements to ensure that they can be modified as needed. To inform redesign, governance health checks can be used to assess whether governance mechanisms are effective.

**Networked governance:** The authorising environments within which smart cities operate are complex, with hierarchical, jurisdictional, multi-level, initiative-based and thematic governance all occurring and potentially overlapping. Some smart cities initiatives may be located within a specific industry policy or industry sectors such as transport or health, while others may span and be linked into multiple sectors/portfolios. Hierarchies also exist within projects, with any given smart city initiative potentially being a composite of numerous technology providers, government agencies and citizen groups interacting through governance mechanisms. It is critical that authority structures for smart cities are developed to be cognisant of these hierarchies and are designed to effectively interact with and operate within existing complex authorising environments.

In the same way that data and systems are increasingly networked, our governance structures need to reflect this reality and respond accordingly. It is therefore recommended that the design of governance

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\(^7\) For an overview of this framework please see [http://prince2.wikidot.com/](http://prince2.wikidot.com/).
arrangements for smart cities ensures that the formal hierarchical governance models are connected with each other, and with the networked governance structures that are more organic and self-organising. These formal hierarchical governance structures (mainly government) must increasingly interact with and leverage the networked governance models around which communities coalesce.

### 6.3.2 Data governance

Perhaps the most critical issues related to institutional arrangements for multi-organisational smart cities initiatives are those around data. Although there are some well-established, industry standards and practices for data governance such as the Data Management Body of Knowledge [70], these are designed primarily for use within individual organisations. Data governance models in multi-organisational contexts and across complex data supply chains, structured in a way that addresses the needs of different kinds of stakeholders, is not well articulated.

Given the variety of data implicated in smart cities, as well as the value of data and potential disbenefits for data providers to share personal data for reuse, there is a recognition that more fine-grained control by providers over the data is important. This would enable data providers to determine how widely different kinds of data were shared, with whom and under what conditions (e.g. for research, commercial use, for free, or for fee). However, for the data aggregator, the sheer volume and complexity of data in circulation means that participating in and making informed decisions about its use is challenging. For example, managing the privacy settings around a single platform such as Facebook can be daunting, particularly given citizens’ level of awareness and understanding of the digital domain. Added to this are complexities and challenges associated with reuse, reidentification, value generation and benefit distribution when data is held in aggregate.

For these reasons establishing governance arrangements, especially for personal data, is challenging. However, there are several developments occurring in this space that hold some promise for addressing these challenges. These include data trusts and data cooperatives.

**Data trusts** are legal structures that provide independent stewardship of data [71]. Responsibility for making decisions about data is delegated to stewards who decide who has access to data, under what conditions and who can benefit from it. Organisations that collect and hold data usually perform this role, but within data trusts the organisations that collect and hold data delegate an independent organisation to make decisions on their behalf about how that data is used and shared for an agreed purpose. Likewise, individuals could delegate responsibility for decisions over their data to data trusts.

Trustees of the data trust are able to make decisions about ‘sharing data in ways that unlock its value, while ensuring these decisions support the purpose of the data trust and the benefits it is intended to bring’ [71]. Thus, data trusts are able to maximise the use of data while retaining the confidence of those sharing data with the trust. A data trust acting as an independent body could greatly assist in reconciling the needs of a diverse set of actors involved in smart cities. The trust could also be used to reduce transaction costs around shared data, and investment in stewardship provides opportunities to access and be innovative with data while ensuring benefits are distributed more widely, ethically and equitably.

**Data (platform) cooperatives** are organisational forms created to manage pooled data resources. Data and platform cooperatives are modelled on the broader cooperative movement that is founded on generative rather than extractive principles. Pooled resources are used to generate benefit for members rather than the value of pooled resources being extracted by data aggregators. Data (platform) cooperatives are emerging in several areas such as agriculture and healthcare. For example, MiData, a Swiss health data cooperative, has established a data exchange to host members’ medical records [72]. It aims to integrate traditional health data with data from FitBit and elsewhere, so that it can be more easily accessed and used for research and other purposes. The ultimate aim is to maximise data value while ensuring that the control and monetisation of personal data flows remains with those who generate it (i.e. the citizens).

**It is recommended that new organisational forms that provide more equitable control and use of shared personal data be explored.** In essence, these mechanisms enable personal data (and other data) to be controlled by the providers, on platforms that lower the transaction costs for providers and users, with decisions about sharing and reuse being made by the data providers as well as by the collectives through
delegated decision authority. Delegated decision-making is based on agreed principles, and on the objectives of the trusts or cooperatives, which both serve their membership. These approaches together with the organisational forms, and the economic framings that underpin them, offer real promise to address some of the challenges around achieving equity in data collection and exchange.

6.3.3 Standards

Data standards play a critical role in enabling interoperability between systems and data, ensuring the efficient flow and use of data. Standards are a form of institution (i.e. rules that govern behaviours); without them the costs of data integration for smart cities would be prohibitively expensive. Standards are an inherently social process involving negotiation and reconciliation of a range of divergent perspectives and practices to co-develop an agreed common approach. Government and industry play critical roles in standards development and adoption. Government can fund standards development where there is market failure and can promulgate standards, mandating their use. Industry plays a key role in developing standards, and in their adoption in the tools, products and services, that they provide. It is recommended that institutional arrangements for smart cities incorporate mechanisms to govern the process of developing and adopting standards. Government should play a key role in facilitating standards where high levels of interoperability are required, and in cases where there is market failure, funding uncertainty, and difficulty in standards development.

6.4 Data platforms for the public good

There are two key recommendations for data platforms:

- Platforms should be conceived of as public utilities that equitably and efficiently provide the public good data underpinning smart cities.
- The total cost of ownership of platforms as sustained infrastructure must be considered beyond the life of the project paying for the initial development.

As noted previously, platform mechanisms enable integration and reduce transaction costs for access to large volumes of data. For smart cities that comprise multiple streams of different kinds of data, economies of scale and efficiencies of access can be realised by bringing together these different types of data. This can be done through a single physical platform or by networking discrete platforms. However, regardless of the technical architecture of these platforms, the economic architecture must be considered.

6.4.1 Platforms as public utilities

Digital platforms can bring significant market power, both within a market through economies of scale, and across markets by providing an informational advantage over third-party providers of goods and services. For example, Amazon’s digital retail platform enjoys major economies of scale, with its fixed costs spread over a very large number of transactions. Although it allows others to access this infrastructure through Amazon Marketplace, it also uses information it gains from these third parties to expand into selling their products directly on their retail platform [73]. There is also a tendency for large providers to achieve vertical integration – from sensors and smartphones directly into platforms – with the aim of creating commercial ‘walled gardens’ around data markets. The owners of the platform are able to control and exploit the data held in their data market and offer (peripheral) apps to their user base. They can invite third-party app developers in under their terms, provide access to the users (as targets for advertising), and then sell data to third parties for profit or reciprocal benefit. For example, the use of Foursquare city data by a competitor may be under commercial terms and require payment for access, or it may be a reciprocal exchange, providing more data about a location back to Foursquare.

In many instances platforms and their data markets are becoming interconnected or merged. However, platforms are somewhat like toothbrushes in that everybody wants one but typically no one wants to use somebody else’s. The big players tend to try to create their own walled gardens, where smaller players tend to partner or enter into commercial arrangements with those holding data of interest, increasing their dominance in the sector. These economic drivers create significant challenges for those attempting to access and integrate data to inform city functioning.
However, there is a significant potential role for government to create the kinds of platforms that are necessary to realise a smart city vision. **It is recommended that smart city platforms are conceptualised and developed as public utilities, under the control of government.** These are platforms that would enable the safe collating and storage of, and access to, several different kinds of data, with fine-grained provider control over data. This set of core platform functions enables potential users of data from state, industry and civil society to discover, access and use data at a low transaction cost, and to value-add to this data. Establishing a data market as a core platform function, with appropriate institutional arrangements, would create an efficient marketplace for the development and provision of value-added services by both the public and private sectors.

A public utility is an organisation that controls and maintains some infrastructure that produces goods broadly consumed by the public. In most cases, the goods produced by public utilities are essential to social and economic wellbeing (i.e. water, electricity, telecommunications). Arguably, platforms such as Amazon’s Marketplace or Google’s search engine play a similarly essential role in the wellbeing of the digital economy. Public utilities are often distinguished by their status as natural monopolies. This arises due to high costs of establishing infrastructure (i.e. establishing and growing the platform) and other market entry barriers, with relatively low ongoing provision costs. As such, natural monopolies can take advantage of cost economies of scale in the provision of resulting goods.

The structural separation of a platform core established as a public utility, and an ecosystem of peripheral functionality provided by whomever is best placed to provide them, make sense from an economic perspective. If government were to establish these platforms, through the development of appropriate institutional arrangements and the governance of the data, it would be possible to achieve equitable outcomes around data collection, collation and use across the government, industry and civil sectors.

This recommendation does not mean that government should build platforms on its own. Rather, it should seek partnerships with technology providers who are able to deliver technical solutions, while the government takes on the role of regulating (setting the rules around data storage, sovereignty, etc.) and funding the operation of the platform.

### 6.4.2 Economic considerations for a public good – oriented platform

Platforms, like any other project, involve costs, benefits and trade-offs. In economic terms, platforms are particularly challenging, as by definition they involve multiple parties, some of whom may incur costs while others accrue benefits. Digital platforms have the potential to generate considerable value. However, we must avoid being seduced by the promises of riches associated with Silicon Valley start-ups. While many platforms have become household names in recent years, most have never made a profit (for example, the much-vaulted Uber is still using venture capital to provide subsidised taxi rides and has never turned a profit) and it is likely that many never will. In too many cases, data is less the new oil than the new snake oil. Platforms – particularly those viewed as a public utility – are unlikely to generate enormous revenue, even if they generate value; however, they do need to have a path to economic self-sufficiency, or what might be referred to as ‘sustainment’.

**Sustainment – avoiding infrastructure orphans**

Sustainment is the continued maintenance and support of a capability. For example, in the military domain, a combat aircraft requires fuel, munitions, runways, hangars and other infrastructure to sustain it to fly combat missions. Sustainment is the provision, planning, deployment and continued operational abilities behind the capability. Sustainment of platforms is not a purely technical endeavour; it also requires a business model that considers network effects, incentives, value and scale, but also social and cultural factors.

In the public sector, where selling a platform for profit is not an option, a platform must be able to sustain itself through a funding source. Furthermore, to justify this funding it must demonstrate value. Without sustained funding, a platform runs the risk of becoming an ‘infrastructure orphan’ – a term used to describe technical systems that have been built through time-limited projects, but that are abandoned or operated under skeleton arrangements due to the inability to create relationships and a sustainable long-term funding stream.
There are a number of salient economic questions around how to sustain a platform. There are the questions around cost: how is a platform being funded; who is providing the capital for both the initial development and longer term operation of a capability? In the public sector this funding can come from a range of sources including public grants or departmental revenue streams (for example, the Business Longitudinal Analysis Data Environment or BLADE, provided by the Australian Bureau of Statistics), through to public/private partnerships with industry entities (Australia’s National Broadband Network is an example of infrastructure built in this way). Neither source of funding is infinite and, once the initial grant has been spent and the early buzz around a project has subsided, maintaining the social and technical architecture will be challenging. Project funding is finite and successful infrastructures need to persist indefinitely. A business model is therefore required that goes beyond initial project funding.

Continued funding is critical to meet ongoing costs such as maintenance, which can be expensive but lacks the glamour of an initial build and launch. These costs also scale with the platform, meaning that a successful platform will be subject to greater maintenance pressures, as it increases in volume of users, data and richness of functionality. It is therefore preferable to avoid building bespoke infrastructure, unless intrinsic socio-technical characteristics, such as security, are required. Wherever possible, infrastructure and platforms should be reused. Existing platforms are likely to be operating at scale, with rich and well-tested functionality.

It is therefore recommended that initiators of smart cities consider the total cost of ownership of platforms and seek from the outset to secure long-term sustained funding and institutional buy-in to platforms.

**Demonstrating value and monetising public platforms**

To ensure ongoing support a platform needs to demonstrate value. For a private sector operator this is usually represented by a cost and benefit analysis; if the ongoing benefits do not exceed the ongoing costs, there is unlikely to be a case for continued investment, unless there is good reason to expect significantly greater benefits in the future. Where a platform is successfully creating value for others, the key questions are whether and how to monetise it. There is no clear answer to this in the public or private sectors. As soon as a platform begins to charge users, transaction costs will be incurred, reducing the overall value created. A platform operator needs to consider how valuable the service is to users, and determine if there are alternative ways to cover costs. Even a valuable service will be hard to monetise if close substitutes are available for free (one reason why public broadcasting sits increasingly uneasily alongside commercial providers).

It is recommended that in attempts to create public good – oriented platforms and data markets government should be cognisant of the need to show and quantify benefit and value, but also realise they are not necessarily constrained by monetary cost-benefit constraints. The public sector can step in where the benefits of a platform exceed the costs, but monetisation is unfeasible, due to the public good nature of the service being provided (e.g. weather forecasts). There may also be a role for public platforms to ensure services are extended to the whole population, rather than limited to those groups who prove most profitable, as is being done for Australia’s National Broadband Network (though this may also be achieved through regulation, if the overall profits are sufficiently high). It is important the monetary costs/benefits be considered, and be seen as affordable, but public platforms can work in different ways provided there is an understanding of the overall social or environmental value they produce or enable.

Monetisation, and the charging for services or access to data, excludes those who are unwilling to pay. For digital products, exclusion is difficult to enforce as they can be copied without cost and distributed (though a combination of socio-technical innovations appears to be reducing digital piracy; for example, personalised access and simultaneous global release). Monetisation also undermines the very purpose of platforms in the public sector by placing transaction costs on services meant for all citizens.

However, without generating revenue, which indicates people are willing to pay for a valuable service, it may be challenging for a public sector platform to demonstrate its case for ongoing investment. In some cases, public sector platforms may save government money through providing services more efficiently. In some of these cases increasing proportions of the costs of service provision may be shifted onto users in the form of ‘self-service’. Attempts should be made to estimate the values being generated on behalf of others (as Sanderson et al. [74] have done for CSIRO’s Data Access Portal). Even where revenue is not an issue, platforms
may struggle to maintain engagement over time. Related to this is ensuring the appropriateness of incentives structures for both the use and uptake of a platform.

A platform cannot, therefore, be viewed as a ‘set and forget’ proposition with investment only required in the set(up) phase. Much work is required to continually develop the platform and maintain a conducive environment for its sustained operation. This also requires significant engagement and nurturing of the social architectures of providers, users and value adder communities around the platform. The phenomena of infrastructure orphans, where platforms are abandoned after creation, partly lies with the failure to incentivise uptake by users and institutions. A perfect piece of technology is useless if no one is using it, making it critically important to find the appropriate levers to encourage uptake, and then sustain use.

Economic and social relationships are critical to the success of a platform if it is to be more than a technical demonstrator. Finding and building value relationships, appropriate cost and funding models, and incentives for use, are not the only economic variables at play; however, they provide the foundations of a sustained platform.
## Appendix A Case studies

Description and assessment of case studies used in the landscape scan.

<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Overall Assessment and Reviewer Comment</th>
<th>Reference (URL, DOI, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>thethings.io</td>
<td>A closed data cloud for closely coupled IoT sensors in supply chain logistics</td>
<td><a href="https://thethings.io/iot-smart-city-platform/">https://thethings.io/iot-smart-city-platform/</a></td>
</tr>
<tr>
<td>3</td>
<td>London Data Store</td>
<td>An open data repository and analytic enabling ecosystem</td>
<td><a href="https://data.london.gov.uk/">https://data.london.gov.uk/</a></td>
</tr>
<tr>
<td>4</td>
<td>The City Data Exchange (CDE)</td>
<td>Copenhagen project implemented by Hitachi to set up city data market for every aspect of tech, energy, civil society; ambitious; but not clear what happened to it; e.g. platform link is broken!</td>
<td>the initiative - <a href="https://cphsolutionslab.dk/en/news/city-data-exchange">https://cphsolutionslab.dk/en/news/city-data-exchange</a>&lt;br&gt;the platform <a href="https://www.citydataexchange.com/#/home">https://www.citydataexchange.com/#/home</a></td>
</tr>
<tr>
<td>5</td>
<td>City Data. Com</td>
<td>A closed data aggregation app</td>
<td><a href="http://www.city-data.com/">http://www.city-data.com/</a></td>
</tr>
<tr>
<td>6</td>
<td>Strava Metro</td>
<td>Strava operated transport intelligence data services platform</td>
<td><a href="https://metro.strava.com/">https://metro.strava.com/</a></td>
</tr>
<tr>
<td>7</td>
<td>European Innovation Partnership on Smart Cities and Communities</td>
<td>Partnership to develop and spread a common open urban data platform for EU citizens by 2025</td>
<td><a href="https://e3p.jrc.ec.europa.eu/articles/european-innovation-partnership-smart-cities-and-communities">https://e3p.jrc.ec.europa.eu/articles/european-innovation-partnership-smart-cities-and-communities</a></td>
</tr>
<tr>
<td>8</td>
<td>Sharing Cities</td>
<td>Urban data sharing platform. Very open API but hard to see how open the platform is. Does it pivot on idea of ‘data trust’? i.e. independent third-party stewardship of data</td>
<td><a href="http://www.sharingcities.eu/">http://www.sharingcities.eu/</a></td>
</tr>
<tr>
<td>9</td>
<td>Open Active</td>
<td>Aggregates data from public and private entities about exercise/sport/fitness activities within different geographies; interesting for mixture of data sources -- municipal services + private operators</td>
<td><a href="https://www.openactive.io/">https://www.openactive.io/</a></td>
</tr>
<tr>
<td></td>
<td>10 RiderLog</td>
<td>A smartphone app that collects data on bike rider movement and behaviour. It appears to be a true data collective, in which individuals actively choose to contribute data to a collective, for no direct personal benefit (though there are indirect benefits through better recognition of cyclists as road users)</td>
<td><a href="https://www.bicyclenetwork.com.au/our-services/riderlog/">https://www.bicyclenetwork.com.au/our-services/riderlog/</a></td>
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<tr>
<td></td>
<td>11 Twitter</td>
<td>Micro-blogging platform. A digital stream of consciousness (for better or worse). Individuals share knowledge, opinions, photos etc. And also like, share or respond to others</td>
<td><a href="http://www.twitter.com">http://www.twitter.com</a></td>
</tr>
<tr>
<td></td>
<td>12 Mass Observation</td>
<td>A big data social research project in the predigital era. Found many people willing to share their experiences (i.e. data); also encouraged eavesdropping on others.</td>
<td><a href="http://www.massobs.org.uk/">http://www.massobs.org.uk/</a></td>
</tr>
<tr>
<td></td>
<td>13 MUV app (CIVITAS EU project)</td>
<td>A mobility app capturing user’s daily commute data with a gaming interface. This EU project has built more than 100 tools over the last 15 years around smart cities</td>
<td><a href="https://www.muvapp.eu/muv/#">https://www.muvapp.eu/muv/#</a> Other tools: <a href="https://civitas.eu/tool-inventory">https://civitas.eu/tool-inventory</a></td>
</tr>
<tr>
<td></td>
<td>14 UberEats</td>
<td>Meal delivery/gig economy application</td>
<td><a href="https://www.ubereats.com/en-AU">https://www.ubereats.com/en-AU</a></td>
</tr>
<tr>
<td></td>
<td>15 Safetipin</td>
<td>Geolocated safety information and decision-making app to make cities safer for women</td>
<td><a href="http://safetipin.com/">http://safetipin.com/</a></td>
</tr>
<tr>
<td></td>
<td>16 Nearify</td>
<td>Social events near you</td>
<td><a href="https://www.nearify.com/">https://www.nearify.com/</a></td>
</tr>
<tr>
<td></td>
<td>17 Sidewalk Labs</td>
<td>Alphabet / Google’s smart city project in Toronto; not a platform yet probably but a noteworthy development.</td>
<td><a href="https://sidewalktoronto.ca">https://sidewalktoronto.ca</a></td>
</tr>
<tr>
<td></td>
<td>18 Organicity</td>
<td>Experimentation as a service? Deliberate effort to encourage ‘collaborative citymaking’</td>
<td><a href="https://organicity.eu/what-is-organicity/">https://organicity.eu/what-is-organicity/</a></td>
</tr>
<tr>
<td></td>
<td>19 CitySDK</td>
<td>Toolkit for attempts to link city data repositories</td>
<td><a href="https://www.citysdk.eu/">https://www.citysdk.eu/</a></td>
</tr>
<tr>
<td></td>
<td>20 The Six City Strategy</td>
<td>This an instance of the CitySDK in use</td>
<td><a href="https://www.citysdk.eu/6aika-open-data-and-interfaces/">https://www.citysdk.eu/6aika-open-data-and-interfaces/</a></td>
</tr>
<tr>
<td>No.</td>
<td>Platform/Initiative</td>
<td>Description</td>
<td>Website Link</td>
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<tr>
<td>21</td>
<td>ANAGOG</td>
<td>A service provider (platform?) for data collection on customer mobility that could be useful for smart city purposes</td>
<td><a href="https://www.anagog.com/">https://www.anagog.com/</a></td>
</tr>
<tr>
<td>22</td>
<td>Data.gov</td>
<td>US government open data platform, has both data and apps</td>
<td><a href="https://www.data.gov/">https://www.data.gov/</a></td>
</tr>
<tr>
<td>24</td>
<td>Nest</td>
<td>Smart Home system</td>
<td><a href="https://nest.com/au/">https://nest.com/au/</a></td>
</tr>
<tr>
<td>26</td>
<td>Wink</td>
<td>Smart Home system</td>
<td><a href="https://www.wink.com/about/">https://www.wink.com/about/</a></td>
</tr>
<tr>
<td>27</td>
<td>Chicago Data Collaborative</td>
<td>A semi-open data platform that details criminal justice system practices in Chicago and presents a window for analytics</td>
<td><a href="https://chicagodatacollaborative.org">https://chicagodatacollaborative.org</a></td>
</tr>
<tr>
<td>28</td>
<td>oneTransport</td>
<td>A data marketplace for transport and smart city related data</td>
<td><a href="https://onetransport.io">https://onetransport.io</a></td>
</tr>
<tr>
<td>29</td>
<td>FuelMap</td>
<td>Open data platform (within Android/iOS environment) for crowdsourcing fuel prices</td>
<td><a href="http://fuelmap.com.au/">http://fuelmap.com.au/</a></td>
</tr>
<tr>
<td>31</td>
<td>AirVisual</td>
<td>A closed data aggregation app that collects, compares and visualises air pollution data from across the world</td>
<td><a href="https://www.airvisual.com">https://www.airvisual.com</a></td>
</tr>
<tr>
<td>32</td>
<td>Array of Things</td>
<td>Collaboration to allow the city to behave like a FitBit for its citizens</td>
<td><a href="https://arrayofthings.github.io/">https://arrayofthings.github.io/</a></td>
</tr>
<tr>
<td>34</td>
<td>Smart cities challenge – Canada</td>
<td>Competition for smart city projects Canada. Has a lot of variations that give shape to different visions of smart city</td>
<td><a href="https://impact.canada.ca/en/challenges/smart-cities/challenge">https://impact.canada.ca/en/challenges/smart-cities/challenge</a></td>
</tr>
<tr>
<td>35</td>
<td>I love Beijing app</td>
<td>Repair reporting and more</td>
<td><a href="https://www.geospatialworld.net/news/beijing-launches-city-management-app/">https://www.geospatialworld.net/news/beijing-launches-city-management-app/</a></td>
</tr>
<tr>
<td>36</td>
<td>Singapore Smart Nation initiative</td>
<td>Government policy initiative for smart city work</td>
<td><a href="https://www.smartnation.sg/">https://www.smartnation.sg/</a></td>
</tr>
<tr>
<td>37</td>
<td>PeerBy</td>
<td>City-centred swapping of stuff</td>
<td><a href="https://www.peerby.com/one">https://www.peerby.com/one</a></td>
</tr>
<tr>
<td>38</td>
<td>Fixmystreet</td>
<td>City maintenance</td>
<td>fixmystreet.com</td>
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<tr>
<td>39</td>
<td>Plenario</td>
<td>City data sharing platform with emphasis on spatio-temporal data; it is a university of Chicago experiment, and managed to elicit datasets from quite a few city governments</td>
<td><a href="http://plenar.io/">http://plenar.io/</a></td>
</tr>
<tr>
<td>40</td>
<td>Boston street bump</td>
<td>City maintenance</td>
<td><a href="http://www.streetbump.org/">http://www.streetbump.org/</a></td>
</tr>
<tr>
<td>41</td>
<td>Metropolitan Integrated Mobility–Montreal (MIMC)</td>
<td>Intermodal transport linkage platform</td>
<td><a href="https://www.makingmtl.ca/4956/documents/16170">https://www.makingmtl.ca/4956/documents/16170</a></td>
</tr>
<tr>
<td>42</td>
<td>Montreal social data hub</td>
<td>Will collect data on the social reality of Montréalers,</td>
<td><a href="https://www.makingmtl.ca/4956/documents/16170">https://www.makingmtl.ca/4956/documents/16170</a></td>
</tr>
<tr>
<td>43</td>
<td>Integrated Local Food System</td>
<td>Create a local circular food economy in Montreal using platform</td>
<td><a href="https://www.makingmtl.ca/4956/documents/16170">https://www.makingmtl.ca/4956/documents/16170</a></td>
</tr>
<tr>
<td>46</td>
<td>Sounds of New York City (SONYC)</td>
<td>A city soundscape/noise pollution annotation/analysis platform for citizens to train algorithms (UrbanEar) by annotating audio clips, that cross decibel thresholds, for pattern recognition</td>
<td><a href="https://wp.nyu.edu/sonyc/">https://wp.nyu.edu/sonyc/</a></td>
</tr>
<tr>
<td>47</td>
<td>Citizen Data Lab</td>
<td>An initiative looking to experiment with participatory data practices for mapping and addressing local issues. This group generates and trials methods, approaches and tools for co-creation to learn about and through data via various projects</td>
<td><a href="http://www.citizendatalab.org">http://www.citizendatalab.org</a></td>
</tr>
<tr>
<td>48</td>
<td>eBird</td>
<td>A citizen science/crowdsourcing initiative to aggregate bird sightings to generate ecological data</td>
<td><a href="https://ebird.org/home">https://ebird.org/home</a></td>
</tr>
<tr>
<td>49</td>
<td>Lime</td>
<td>Location-based dockless e-scooter/e-bike rental company</td>
<td><a href="https://www.li.me/about-us">https://www.li.me/about-us</a></td>
</tr>
<tr>
<td>50</td>
<td>Uber</td>
<td>Fee for service transport company for the transport of passengers and goods (Uber Freight, UberEats)</td>
<td><a href="https://www.uber.com">https://www.uber.com</a></td>
</tr>
<tr>
<td>51</td>
<td>Bird</td>
<td>Location-based dockless e-scooter rental company. Retailing scooter and associated service services to customers</td>
<td><a href="https://www.bird.co/">https://www.bird.co/</a></td>
</tr>
<tr>
<td>52</td>
<td>Ola</td>
<td>Online Cab aggregator - Transport company connecting car for hire services to customers</td>
<td><a href="https://ola.com.au/">https://ola.com.au/</a></td>
</tr>
<tr>
<td>53</td>
<td>GoGet</td>
<td>A Car Sharing service which operates much like a rental service. However, the cars are booked via web/app and unlocked via a keycard supplied to registered users. Users must register and provide a number of details in return they are vetted and supplied with a small keycard that operates the locking mechanism of the vehicle. Vehicles are charged at an hourly/daily rate with some included kilometres per hour or day. Petrol is included and the cars come with a fuel card. Cars are located at designated pickup/setdown areas through the urban area and at high traffic location (airports)</td>
<td><a href="http://www.goget.com.au/">http://www.goget.com.au/</a></td>
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<td><strong>54</strong></td>
<td><strong>Gyroscope</strong></td>
<td>Described as a 'dashboard for your life', this app enables the user to conduct various forms of self-tracking. Data is presented as a transformative medium for all manner of self-improvement projects e.g. thinking clearer, getting stronger, losing bodyfat etc. As the site says, &quot;Gyroscope makes it effortless to track and improve everything about your health. Understand what your body is saying, get warnings before things get serious, and stay motivated by competing with friends!&quot;</td>
<td><a href="https://gyroscope.pe">https://gyroscope.pe</a></td>
</tr>
<tr>
<td><strong>55</strong></td>
<td><strong>Car Next Door</strong></td>
<td>Peer-to-peer car sharing service</td>
<td><a href="carnextdoor.com.au">carnextdoor.com.au</a></td>
</tr>
<tr>
<td><strong>56</strong></td>
<td><strong>Spacer</strong></td>
<td>Peer-to-peer space sharing service</td>
<td><a href="spacer.com.au">spacer.com.au</a></td>
</tr>
<tr>
<td><strong>57</strong></td>
<td><strong>Kerb</strong></td>
<td>Peer-to-peer parking space sharing service</td>
<td><a href="www.kerb.works">www.kerb.works</a></td>
</tr>
<tr>
<td><strong>58</strong></td>
<td><strong>Here (We Go)</strong></td>
<td>Mapping, transport and navigation application</td>
<td><a href="wego.here.com">wego.here.com</a></td>
</tr>
<tr>
<td><strong>59</strong></td>
<td><strong>Onstar</strong></td>
<td>In-Car subscription-based concierge service</td>
<td><a href="www.onstar.com">www.onstar.com</a></td>
</tr>
<tr>
<td><strong>60</strong></td>
<td><strong>LINZ</strong></td>
<td>New Zealand Government Department for Geospatial Information management, land survey and land transfers, managing crown land</td>
<td><a href="https://www.linz.govt.nz/">https://www.linz.govt.nz/</a></td>
</tr>
<tr>
<td><strong>61</strong></td>
<td><strong>openstreetmap.org</strong></td>
<td>Collaborative project to produce a free editable world map</td>
<td><a href="https://www.openstreetmap.org/">https://www.openstreetmap.org/</a></td>
</tr>
<tr>
<td><strong>62</strong></td>
<td><strong>WeGovNow</strong></td>
<td>Platform developed to encourage &quot;WeGovernment&quot;</td>
<td><a href="https://wegovnow.eu/">https://wegovnow.eu/</a></td>
</tr>
<tr>
<td><strong>63</strong></td>
<td><strong>Pokémon Go</strong></td>
<td>A multi-player augmented reality mobile gaming platform that overlays a virtual or simulated surface on the physical environment and encourages players to capture pokémon and complete a Pokedex index. Players can expend money in the game and the platform can extract their geolocative data. Operates a 'freemium business model'</td>
<td><a href="https://www.pokemongo.com/en-au/">https://www.pokemongo.com/en-au/</a></td>
</tr>
<tr>
<td><strong>64</strong></td>
<td><strong>Flu Near You</strong></td>
<td>A participatory surveillance platform where citizen scientist users both self-report and see national distributions of flu symptoms on a virtual map. Created by epidemiologists at Harvard, Boston Children’s Hospital and The Skoll Global Threats, the platform describes itself thus: 'We analyse thousands of reports and map them to generate local and national views of influenza-like illness, providing public health officials and researchers with real-time, anonymous information that could help prevent the next pandemic. With your help, we can all see what’s coming and better still you have the knowledge to protect yourself and your family against disease.' A virology platform</td>
<td><a href="https://flunearyou.org/#1/">https://flunearyou.org/#1/</a></td>
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<tr>
<td>65</td>
<td><strong>Sickweather</strong></td>
<td>Sickweather is a 'social Listening' app that ambently but proactively scans social networks such as Twitter and Facebook to see where people are reporting that they're sick, but also used crowdsourcing, and then gives an area a &quot;sick&quot; rating based on that data [scorecarding and colour-coding]. It is in the business of 'sickness forecasting' and administering 'Population Health 2.0'</td>
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<td>66</td>
<td><strong>Bet365</strong></td>
<td>Online betting and gambling platform</td>
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<td>67</td>
<td><strong>FitBit</strong></td>
<td>Fitbit city fitness ratings have fine-grained reports on heart rates, sleep, steps, etc. over time; 100 million users</td>
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<tr>
<td>68</td>
<td><strong>Feedback2Go</strong></td>
<td>An app to provide feedback on transport experience in NSW</td>
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<td>69</td>
<td><strong>Noise tube</strong></td>
<td>Citizen Science project to track noise pollution in urban environments</td>
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<td>70</td>
<td><strong>Safecast</strong></td>
<td>Citizen science project to track radiation fallout in and about Fukushima post- reactor failure</td>
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<td>71</td>
<td><strong>Police Data Initiative</strong></td>
<td>Project initiated in the US to address the lack of open policing data</td>
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<tr>
<td>72</td>
<td><strong>Flight Aware</strong></td>
<td>Live flight tracking service</td>
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<tr>
<td>73</td>
<td><strong>Kansas Smart City</strong></td>
<td>Using CISCO Kinetic IoT platform</td>
<td></td>
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<tr>
<td>74</td>
<td><strong>Deloitte CitySynergy</strong></td>
<td>“an integrated city operating system”</td>
<td></td>
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<tr>
<td>75</td>
<td><strong>Smart Columbus Operating System</strong></td>
<td>Essentially a data repository (like open.daya.gov ckan instances) but purports to be an open data platform for smart cities. Does support Jupiter notebooks</td>
<td></td>
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<tr>
<td>76</td>
<td><strong>Huawei Smart City Platform</strong></td>
<td>Huawei smart city platform offering</td>
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<tr>
<td>77</td>
<td><strong>tinder</strong></td>
<td>Location aware social/dating app</td>
<td></td>
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<tr>
<td>78</td>
<td><strong>happn</strong></td>
<td>Location aware like app - 'find the people you've crossed paths with'</td>
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<tr>
<td>79</td>
<td><strong>grindr</strong></td>
<td>Geosocial networking and dating app - primarily targeting LGBTIQA+ users</td>
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<tr>
<td>80</td>
<td><strong>Foursquare</strong></td>
<td>Foursquare comprises a city guide data market and app, &quot;the most trusted, independent location data platform for understanding how people move through the real world&quot;</td>
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<td>Data Platforms for Smart Cities</td>
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<td>81</td>
<td>AT&amp;T</td>
<td>Multi-level approach including operations centre, infrastructure/sensors and control. Probably the key element is the 'operations centre'</td>
<td><a href="https://www.business.att.com/categories/smart-cities.html">https://www.business.att.com/categories/smart-cities.html</a></td>
</tr>
<tr>
<td>82</td>
<td>IBM Watson IoT</td>
<td>A fully managed, cloud-hosted service with capabilities for device registration, connectivity, control, rapid visualisation, data storage and predictive analytics. 'We are a fully managed, cloud-hosted service that is designed to simplify and derive the value from your IoT devices'</td>
<td><a href="https://www.ibm.com/cloud/watson-iot-platform">https://www.ibm.com/cloud/watson-iot-platform</a></td>
</tr>
<tr>
<td>83</td>
<td>Microsoft Azure IoT</td>
<td>Vertically integrated cloud-hosted platform</td>
<td><a href="https://azure.microsoft.com/en-gb/services/iot-hub/">https://azure.microsoft.com/en-gb/services/iot-hub/</a></td>
</tr>
<tr>
<td>84</td>
<td>KAA Enterprise IoT platform</td>
<td>Glue for integration of many layers and elements</td>
<td><a href="https://www.kaaproject.org/smart-city">https://www.kaaproject.org/smart-city</a></td>
</tr>
<tr>
<td>85</td>
<td>Bosch (Robert Bosch GmbH)</td>
<td>Bosch provides smart city ‘solutions’ along lines of mobility, energy, safety and security, e-governance, and buildings - in rough alignment with Bosch’s existing business interests. Large diversity of products and services provided, reflecting enormous diversity in services Bosch provides. Many solutions are integrated with existing interest. E.g.- Bosch has powertrain manufacturing business, fits very well with automated parking solutions, which in turn utilise sensor products they manufacture</td>
<td><a href="https://www.bosch.com/products-and-services/connected-products-and-services/smart-cities/">https://www.bosch.com/products-and-services/connected-products-and-services/smart-cities/</a></td>
</tr>
<tr>
<td>86</td>
<td>Telstra</td>
<td>Telstra is moving into smart cities space, leverage its telecommunications network, data centres, smart home networks with its own and others' components to build smart cities. Telecommunications providers such as Vodaphone and AT&amp;T are moving in similar directions</td>
<td><a href="https://www.telstra.com.au/smart-home">https://www.telstra.com.au/smart-home</a> <a href="https://www.telstra.com.au/business-enterprise/solutions/internet-of-things">https://www.telstra.com.au/business-enterprise/solutions/internet-of-things</a></td>
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<tr>
<td>88</td>
<td>Texas Instruments (sensor makers)</td>
<td>Microprocessors, sensors, electronic manufacturer - Making lots of sensors but can't see integration of them</td>
<td><a href="http://www.ti.com/">www.ti.com/</a></td>
</tr>
<tr>
<td>89</td>
<td>Nokia Impact</td>
<td>Mainly to help telecommunications providers to start managing IoT</td>
<td><a href="https://onestruct.nokia.com/asset/205513">https://onestruct.nokia.com/asset/205513</a></td>
</tr>
<tr>
<td>90</td>
<td>CISCO Kinetic for Cities</td>
<td>Data network and integration platform from CISCO; other big companies (especially those in the network business in the broader sense) have similar platforms e.g. Nokia, InterDigital, IBM, Bosh, Verizon) Offers sensor data aggregation, Viz and an open ecosystem to plug in platform</td>
<td><a href="https://www.cisco.com/c/en_us/solutions/industries/connected-communities/kinetic-for-cities.html?dtid=osscdc000283#~stickynav=5">https://www.cisco.com/c/en_us/solutions/industries/connected-communities/kinetic-for-cities.html?dtid=osscdc000283#~stickynav=5</a></td>
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<tr>
<td>91</td>
<td>Siemens Mindsphere</td>
<td>MindSphere is a scaleable cloud-based platform as a service (PaaS) or ‘operating system for the IoT’. It connects products, plants, systems, and machines, enabling IoT/sensor data to be collected and brought into relation with each other and subject to with advanced analytics</td>
<td><a href="https://new.siemens.com/global/en/products/software/mindsphere.html">https://new.siemens.com/global/en/products/software/mindsphere.html</a></td>
</tr>
<tr>
<td>92</td>
<td>Philips HealthSuite</td>
<td>HealthSuite, supported by salesforce.com, is an open, cloud-based platform, which collects, compiles and analyses clinical and other data from multiple devices and sources. An open IT infrastructure that supports the secure management of data related to a person’s health and lifestyle, as well as large scale clinical data</td>
<td><a href="https://www.philips.com.au/healthcare/innovation/about-health-suite">https://www.philips.com.au/healthcare/innovation/about-health-suite</a></td>
</tr>
<tr>
<td>93</td>
<td>Interact IoT Platform</td>
<td>Secure, scalable, LED and embedded sensor platform</td>
<td><a href="https://www.interact-lighting.com/global/what-is-interact">https://www.interact-lighting.com/global/what-is-interact</a></td>
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<tr>
<td>No.</td>
<td>Platform Name</td>
<td>Description</td>
<td>Website</td>
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<tr>
<td>94</td>
<td>ATIS smart cities Data Exchange</td>
<td>Cities and industry to work together to develop a consistent approach to exchanging IoT data.</td>
<td><a href="https://www.atis.org/scde/">https://www.atis.org/scde/</a></td>
</tr>
<tr>
<td>96</td>
<td>Microsoft City Next</td>
<td>Integrated suite of smart cities services that cover a scale of clients from local and national defence clients. Range of apps and platform that provide a variety of services including health, security, infrastructure, finance and transport</td>
<td><a href="https://www.microsoft.com/en-au/enterprise/government/smart-cities">https://www.microsoft.com/en-au/enterprise/government/smart-cities</a></td>
</tr>
<tr>
<td>97</td>
<td>AURIN</td>
<td>The Australian Urban Research Infrastructure Network – a collaborative urban data research platform, one stop online Workbench to many spatial and statistical modelling/planning/visualisation</td>
<td><a href="https://aurin.org.au/">https://aurin.org.au/</a></td>
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<tr>
<td>98</td>
<td>AirBnB</td>
<td>Home sharing platform</td>
<td>airbnb.com</td>
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<tr>
<td>99</td>
<td>Traffic and Environmental Zone/Ring of Steel</td>
<td>CCTV systems for London - is this a platform? unclear, but opens a space for platforms.</td>
<td><a href="https://citysecuritymagazine.com/police-partnerships/city-of-london-police-ring-of-steel/">https://citysecuritymagazine.com/police-partnerships/city-of-london-police-ring-of-steel/</a></td>
</tr>
<tr>
<td>100</td>
<td>Smart Cities Mission</td>
<td>Indian government national programme</td>
<td><a href="http://smartcities.gov.in/content/">http://smartcities.gov.in/content/</a></td>
</tr>
<tr>
<td>101</td>
<td>Songdo smart city</td>
<td>Korean government led, build-from-scratch project</td>
<td><a href="http://songdoibd.com/">http://songdoibd.com/</a></td>
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<tr>
<td>102</td>
<td>Google Maps</td>
<td>Google supported mapping article with route planning and information features</td>
<td>maps.google.com</td>
</tr>
<tr>
<td>103</td>
<td>TripView</td>
<td>Journey planning, transport information display for Australian public transport</td>
<td><a href="https://www.grofsoft.com/tripview.php">https://www.grofsoft.com/tripview.php</a></td>
</tr>
<tr>
<td>104</td>
<td>DiDi Rider</td>
<td>Platform-based transportation services, including taxi hailing, private car hailing, social ride sharing and bike sharing</td>
<td><a href="https://www.didiglobal.com/au/">https://www.didiglobal.com/au/</a></td>
</tr>
<tr>
<td>105</td>
<td>My Location: GPS Maps, Share &amp; Save Locations</td>
<td>Social navigation and mapping application</td>
<td><a href="https://play.google.com/store/apps/details?id=com.location.test">https://play.google.com/store/apps/details?id=com.location.test</a></td>
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<tr>
<td>106</td>
<td>Waze</td>
<td>GPS Navigation - turn-by-turn navigation information and user-submitted travel times and route details, while downloading location dependent information over a mobile telephone network - Owned by Google</td>
<td><a href="https://waze.com/">https://waze.com/</a></td>
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<tr>
<td>107</td>
<td>Transit: Real-Time Transit App</td>
<td>Travel companion and assistance; aggregator, planner, reminder, for multiple sources</td>
<td><a href="https://transitapp.com/">https://transitapp.com/</a></td>
</tr>
<tr>
<td>109</td>
<td>Citymapper - Transit Navigation</td>
<td>Transit convenience, assistance and support app</td>
<td><a href="https://citymapper.com">https://citymapper.com</a></td>
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</tbody>
</table>

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References


