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Public value mapping in the smart city: Assessing emerging urban technologies

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ABSTRACT

City governments must increasingly grapple with how to assess and deploy new and often disruptive technologies to advance public policy goals and community needs. While technology companies assert the transformative change smart technologies offer, significant tensions exist between the market values sought by industry and the public values that city governments are responsible for supporting. In this paper, we analyze two smart city technology cases – facial recognition in Portland, Oregon and autonomous vehicles in Tempe, Arizona – using public value mapping, a concept from public administration and science policy. This process allows for an evaluation of the mismatch between public values and market values. The two case studies show two different approaches to governing emerging technologies and different trajectories based on previous policy efforts. Our analysis suggests that increased cooperation between government, the public, and industry can benefit both public and private interests in relation to public value goals. Through our analysis of these case studies, we also demonstrate how public value mapping can be applied in practice by urban planners and other policy makers tasked with implementing smart city technologies. Public value mapping adds to an increasingly diverse toolkit available to policy makers to ensure that the development of policies and plans that more closely align technology deployment with public value outcomes.

1. Introduction

Smart city technologies promise to deliver municipal services more effectively, manage resources more efficiently, and attract economic investment. Many technology corporations and urban leaders promote these as the only viable solution to urban challenges. Critical social science scholars and civil rights organizations, however, voice concerns over privacy, racial and gender biases, technological solutionism, and the reification of capitalist political economic structures (Clark, 2020; Green, 2019; Sadowski & Bendor, 2019). Amidst these debates, city government officials and staff are attempting to make sense of the risks and opportunities smart city technologies offer and are actively developing plans and policies to manage them. At the same time, city governments often lack the staff, resources, capacities, and expertise to conduct assessments across a range of new technologies and potential public benefits.

While cities play a central role in shaping policy for emerging technologies, national policy and national governments also have an important role to play in catalyzing smart cities projects (Caprotti & Cowley, 2019; Joss, Cook, & Dayot, 2017; Taylor Buck & While, 2017). Their purpose is to facilitate the smart city economy for the companies that produce these technologies and to support local governments to adopt them. This highlights the market-driven approach to policy-making inherent in smart city projects.

However, there are often tensions between the market values promoted by corporations selling smart city technologies and the public values that municipalities are responsible for in the use and implementation of these technologies (Goodman & Powles, 2019; Green, 2019). Critiques of corporate-driven smart cities and their embedded techno-politics are plentiful (Clark, 2020; Kitchin, 2016; Miller, 2020) and highlight numerous challenges cities face. In the last few years, there has been a shift in smart city approaches (Engelbert, Ersoy, van Bueren, & van Zoonen, 2022; J. Lee, Babcock, Pham, Bui, & Kang, 2023), with cities such as Boston, Portland and Toronto pushing back against corporate smart cities.

But these cities remain exceptions and there is a lack of professional

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and academic work that engages with the real challenges that city governments and communities encounter as they try to assess the value, risks, uncertainties, and potential implementation pathways of new technologies. Smart city assessment is an important dimension of this, and numerous frameworks have been suggested (Al-Alwani, 2018; Fernandez-Anez, Velazquez, Perez-Prada, & Monzón, 2020; Khatibi et al., 2022; S. H. Lee, Lee, & Lee, 2019). However, Meijer, Gil-Garcia, and Bolívar (2016) argue that assessment of public value in smart city projects remains an unresolved research question that few scholars have addressed (Castelnovo, Misuraca, & Savoldelli, 2016; Cosgrave, Tryfonas, & Crick, 2014). Work on smart city assessment of public values has been largely academic, but there is also a need for city staff and local communities to have resources, tools, capacities, and expertise to assess and manage emerging technologies to support public values and achieve community goals.

The aim of this paper is thus two-fold. First, we develop a framework to evaluate public value of smart city technologies. For this, we use public value mapping (PVM) (Bozeman, 2007) as a tool to identify where and how smart city technologies are best positioned to provide public value to local communities. We apply PVM to two case studies – autonomous vehicles in Phoenix, Arizona and facial recognition technology in Portland, Oregon. Through these, cases, we demonstrate the tensions between market values and public values. This analysis serves our second aim of developing a process (or tool) that policymakers can use to evaluate emerging technologies. We propose that PVM can support city staff and local communities in their efforts to wade through the hype and uncertainty associated with smart city technologies and examine the extent to which they can be used to generate public value and achieve public goals in their own communities. This paper contributes to the theoretical development of PVM as a concept and to critiques of corporate smart city projects, as well as to the practical development of tools which can be used within a policy making process.

In the following sections, we first discuss what the smart city is along with its critiques, which highlight the disconnect between market value and public value in smart city projects. We then introduce public value mapping and application within a smart city context. Next, we use the PVM framework to explore two smart city technology cases: facial recognition technology in Portland, Oregon and autonomous vehicles in Phoenix, Arizona. We conclude with a discussion of both the implications of our PVM evaluation on the cases and on how PVM can be used by city staff – urban planners, smart technology offices, etc. – and others as a tool to better assess how emerging technologies can be used to address issues of public concern.

2. Public values and smart cities: what is the value?

Cities (as social, geographically spatial and economically bounded organizations) face complex challenges related to sustainability, equity, resilience, urban mobility, and other issues. The smart city is an urban development model that has emerged as a dominant strategy that aims to address these issues with a technology-centric approach (Angelidou, 2015). Increasing neoliberalization and privatization in cities fueled a corporate model of smart cities in which technology companies propose innovative solutions to these complex urban problems. Technology companies have positioned themselves as relevant and powerful players in urban development by offering seemingly technical and apolitical solutions to complex urban challenges (Miller, 2020; Sadowski, 2016). The smart city, as a development process, places value on concepts such as innovation, experimentation, collaboration, efficiency, monetization of data, data-driven decision-making, and techno-solutionism (Albino, Berardi, & Dangelico, 2015; Hollands, 2008).

Companies that produce smart city technologies identify urban challenges through the lens of the technologies they produce. Within this emerging international urban development paradigm, technology companies and others present a reality where cities lack sound, relevant and necessary flows of data (Barns, 2024; Söderström & Datta, 2024) to create solutions by themselves. This framing is not introduced to pursue a long-term procurement commitment, but rather in the language of experimentation, collaboration and innovation (Caprotti & Liu, 2022; Cugurullo, 2021; Perng & Maalsen, 2020; Quan & Solheim, 2023). Numerous scholars have highlighted this corporate-driven narrative, along with its aims and implications (Clark, 2020; Kitchin, 2016; Miller, 2020), which highlights the numerous challenges cities face.

Lacking the resources needed to maintain complex technological infrastructures and systems, cities have increasingly allowed technology companies to operate alongside traditional municipal services in new forms of public private partnerships (McAslan, Najar Arevalo, King, & Miller, 2021; Quan & Solheim, 2023). This phenomenon has been termed the corporate smart city in the academic literature (Sadowski & Bendor, 2019) and is evidence in the multitude of public-private partnerships where smart city companies test technologies with the local city government in the shape of experimentation (Caprotti & Liu, 2022). In this process, the conception of public participation becomes subsumed into a post-political process favoring instrumental processes over political processes that challenge the rationalities that shape issues (Cardullo & Kitchin, 2019a; Perng & Maalsen, 2020). The rapid evolution and onslaught of smart city technologies has not helped as municipal governments try to keep up, accommodate their governance and accept pilot and experimental projects. Other ways smart cities are implemented are in the practices of retrofitting, repurposing, and reinvigorating (Perng & Maalsen, 2020).

Within this corporate smart city model, the application of technology further shifts urban governing into a technocratic framework (Bina, Inch, & Pereira, 2020; Kitchin, 2014). Complex urban problems that would normally require a political response are instead addressed with a technocratic set of solutions (Verrest & Pfeffer, 2019). Smart cities become aspirational, apolitical, and technological projects where resources and services are optimized, decisions are data-driven, objectivity drives policies, and knowledge to anticipate future challenges is generated in relationship to these data. Yet, as research from science and technology studies and other fields has shown, these technocratic, data-driven approaches carry with them techno-political aspirations and biases (Benjamin, 2019; Miller, 2020; Sadowski, 2016).

Smart city technologies now impact all aspects of urban life. Early projects included control room with city-wide surveillance and monitoring capabilities (Gaffney & Robertson, 2018). Today, smart city technologies permeate urban development processes, including building technologies, environmental monitoring, transport and mobility, public safety, public health, education, housing, and even public participation and civic engagement (Mohanty, Choppali, & Kougianos, 2016; Sen, Eggers, & Kelkar, 2018). Well-established technology companies and start-ups approach cities offering technological solutions to improve how the city operates and lower the costs of providing services. It is hard for many cities to resist such win-win scenarios.

Numerous smart city critiques have emerged. Concerns have been raised about the politics of urban big data, technocratic governance, corporatization of city governance and technological lock-in, failure and security of digital cities, and issues of surveillance (Kitchin, 2014; Leszczynski, 2016). Others have shown how urban test-beds and data gathering technologies, and other smart city projects obscure and reinforce embedded political economic values and structures (Halpern, LeCavalier, Calvillo, & Pietsch, 2013; Mattern, 2017; Miller, 2020). Others have argued that highly digitized systems are a new form of digital capitalism (León & Rosen, 2020; Mahmoudi & Levenda, 2016; Sadowski, 2019, 2020) and that smart city projects reinforce existing and create new geographies of uneven development (Clark, 2020).

Alvarez León and Rosen (2020) argue that “the turn toward smart cities, emphasizing solutions, services, and infrastructures driven by digital technologies, has reinforced a dominant ideology shaping urban decision making, frameworks, and outcomes.” The smart city is thus based on techno-solutionism and techno-managerialism of city processes and priorities rather than how technologies are deployed and the public benefits they might generate (Miller, 2020). Within this context, critics argue there is little to no incentive or likelihood of smart city projects generating broad based public value benefits.

Since 2020, we have seen a shift in how smart cities are enacted in policy and in the built environment, with cities like Boston, Portland, Barcelona, and Toronto and pushing back against the corporate smart cities narrative and taking note of the growing (academic) critiques of corpora smart cities. Particularly well-known is the case of Toronto where Google and Sidewalk Labs had developed a smart city vision for the Toronto waterfront (Flynn & Valverde, 2019). By 2020, when Sidewalk Labs' plans for the waterfront were abandoned, the project had received opposition from the public and elected leaders about issues such as privacy, inclusion, and corporate control (Filion, Moos, & Sands, 2023). This case has contributed to the critical scholarship of corporate visions of the smart city and some cities chose alternative paths. Barcelona, for example, pioneered the concept of technological sovereignty, a public value that guided its approach to its Digital City plan (Mann, Mitchell, Foth, & Anastasiu, 2020) which prioritizes the city's and residents' authority on technological choices over corporate ones.

Smart cities scholarship offers thorough critiques of the corporate smart city model and many cities have begun to forge alternative paths to leverage the benefits of new technologies. They have moved beyond techno-solutionism and are doing more to work with communities and to focus on the potential public values and needs that can be serviced and supported by smart city technologies. Within smart city research, numerous scholars have addressed the issue of public value, with many discussing the processes by which cities may create public value. Among these include are greater political / public participation (Lim, Malek, & Yigitcanlar, 2021; Neuroni, Haller, van Winden, Carabias-Hütter, & Yildirim, 2019), collaborative innovation (Neumann, Matt, Hitz-Gamper, Schmidthuber, & Stürmer, 2019), and (open) data infrastructure (Neuroni et al., 2019; Pereira, Macadar, Luciano, & Testa, 2017).

Importantly, Pereira, Luna-Reyes, and Gil-Garcia (2020) demonstrate that public value is not generated by technology alone, but that it also stems from the capacity of the government to enable transformations (e.g. technological capacity and human resource capacity) and from governance structures themselves that enable openness and democratic decision-making. They also show how the goals of smart cities, such as efficiency, better decision-making, transparency, participation, or sustainability, can also be seen as public values (Pereira et al., 2020). In this way, corporate values are encoded in the smart city projects themselves. However, if we accept that public value is generated through public discourse, the public values of smart city projects cannot be decided in a top-down approach by technology companies. It is therefore important to link smart city technologies to already existing community goals, which may of course overlap with other conceptualizations of 'value'.

Additionally, while these studies discuss the conditions for generating public value, none offer tools to evaluate or assess that public value. In the next section, we discuss the concept of public value mapping, which we propose as a possible tool that can be used as one potential framework and tool to deliberate and to bridge research and practice in the smart city to analyze the potential public benefits and public values of smart technology critically and proactively in our cities. We argue that PVM can be used by policy makers to assess public value of new technologies within the planning process itself, which we demonstrate through the use of PVM on two case studies – autonomous vehicles and facial recognition technology.

3. Public value, market values and public value mapping

Public values and market values are ways to normatively frame how to address societal challenges, such the challenges cities face when adopting emerging technologies. Bozeman (2007) defines public values as "those providing normative consensus about the rights, benefits and prerogatives to which citizens should (and should not) be entitled; the obligations of citizens to society, the state, and one another and the principles on which governments and policies should be based" (Bozeman, 2007, p.13). Public values can also be defined as societal aspirations not easily defined in economic terms (Fisher, Slade, Anderson, & Bozeman, 2010). Public value was proposed by Moore (1995) as a concept to bring organizational approaches from the private sector into public administration, for example interpreting residents and citizens they serve as clients and considering the value that could be delivered to them by using strategic management approaches. However, Moore (2013) reflects on the limitations of the application and the transactional nature of this approach, stating:

"In the end, what makes social outcomes valuable is not simply that particular individuals value them, but that the wider 'public' that has tacitly agreed to be taxed and regulated to produce the desired social result values them. This suggests that in the public sector, the relevant 'customer' is a collective public (local, regional, or national) acting through the imperfect processes of representative democracy rather than an individual consumer making choices about what to buy for personal benefit". (Moore, 2013, p.3)

Bozeman continued Moore's legacy on the need to have a blueprint to guide public administration work based on the public interest, hence defining public value as what a society collective aspires to be and have and its normative lenses. In contract to public value, Bozeman (2007) defines market values as being the product of "market failure theory reasoning, which is the idea that market like approaches is often the most useful way for governments to provide goods and services" (Bozeman, 2007, p.16). Critiques on techno-solutionism and smart cities constitutes a grounding start to explore market values in the smart city proposals proposed by technology companies. Smart city technology companies identify market failures (naming a market gap or need they see) and develop solutions within this reasoning to generate value. City governments have the goal to serve the public interest and navigate pressing urban challenges, which contribute to public values.

The dichotomy between public values and market values implies a tension or 'ideological mismatch' (Lodato & DiSalvo, 2018), but it is possible that public values and market values can be aligned. Here is where definitions of public versus market values is important. While both the public and private interests may value 'sustainability', for example, how they define what sustainability is can vary greatly. Considering smart cities, it is also important to ensure that public values – those collective societal values that are democratically decided – are not coopted by city administrations to justify particular strategies that may align more closely with private market interests of technology companies. It is essential to minimize corrupt interests or the misuse of public funds (Cardullo & Kitchin, 2019b; Dobson & Parker, 2023; Kamols, Foth, & Guaralda, 2021; Monno & Khakee, 2012) when implementing smart city technology. Assessment can fill this role at various stages of implementation to identify what values are being met and if they align with public values, and public value mapping can help meet this need.

Public value mapping (PVM) has emerged over the last decade as a counterweight to the dominance of efficiency and economic individualism in the evaluation of public policies and investments. PVM was developed by Bozeman (2007) as part of a new form of public administration called managing publicness – an approach to governance that centers on public value or seeks to deliver public value. Managing publicness is a critique of new public management (NPM), which is a public administration framework based on economic individualism in which public policies, design, evaluation, and analysis are based on market theories. Bozeman critiques the market roots of NPM because of failures that occur in markets and the inapplicability of markets to the government. Within 'managing publicness', PVM is not a decision-making tool (á la cost-benefit analysis), but a framework for identifying public value criteria potentially useful for public debate and policy deliberation about public value and its relation to economic value.

PVM explores the relationship and tension between public value and market value which 'map' into four quadrants. The quadrants then are (1) market success / public success, (2) public success / market failure, (3) market failure / public failure, and (4) public failure / market success. A public values failure occurs when "the market and the public sector fail to provide goods and services required to achieve the core values of society such as equity" (Bozeman, 2007, p.145). Public values failure occurs due to flawed policymaking processes where there are insufficient means of ensuring articulation and effective communication of core values or if processes for aggregating values lead to distortions. Importantly, public value failures are not in strict opposition to market successes, but instead occur when neither the market nor public sector provides goods and services required to achieve public values (Bozeman & Sarewitz, 2011).

PVM has been used to analyze public programs, policy decisions, regulations and explore scenarios. It has also been leveraged in deliberative spaces to discuss science and science policies (Bozeman & Sarewitz, 2005, 2011; Bozeman & Youtie, 2017). PVM has been applied to assess emerging technologies such as nanotechnology (Bozeman & Sarewitz, 2011; Fisher et al., 2010) or genetically modified foods (Bozeman, 2007) and in environmental assessments (Foley, Pollack, Barrella, & Wilkins, 2021; Williams, Kang, & Johnson, 2016). PVM analysis is useful in technology and policy assessment because its objective is to encourage deliberation, discussions around public values articulation and aggregation. Criteria of PVM analysis include mechanisms for values articulation and creation, legitimate monopolies, imperfect public information, distribution of benefits, provider availability, time horizon, substitutability versus conservation of resources, and ensuring subsistence and human dignity.

While this assessment has been widely applied to case studies in the national or federal scale, our proposal is to explore it to understand the potential applications to the work that local and regional governments do, particularly city governments. This paper is just a start of how it could be relevant in research of past case studies looking at technology assessment in the context of smart cities.

4. Research methodologies

This paper is a qualitative analysis of two case studies of a smart city technology in a particular place. We examine the deployment of autonomous vehicles in the Phoenix metropolitan area, with a focus on Tempe, Arizona and the adoption of facial recognition technology in Portland, Oregon. Our analysis relies on identification of public values and on in-depth examinations of the policies and actions that guide the use of these technologies. Public values were identified through multiple sources, including from city websites and other public documents from both cities. These include mission statements, laws, policies, regulations, planning documents in each of the cities. Here, we consider public values to be broad statements about important issues, community goals, or more ideological stances on different issues. We draw on a range of public documents to identify both broad public values and those specifically relevant to both case studies. It was also important that these public values be informed through participatory processes.

In our analysis of the cases themselves, we draw on a wide range of documents, including plans, reports, city council meeting materials, and other publicly available documents. We also incorporate interviews and conversations with city staff in both cities about the specific technologies being examined. We also use media reports and news articles about the use of these two technologies in both cities. From our analysis of these documents, we identify key policy events in both cities, which impact the overall deployment and use of the technologies themselves. We then map these events using the public value mapping framework, weighing the level of market failure versus success and the public success versus failure.

In addition to mapping the key policy events in both cases, we further develop the public value mapping method by considering and incorporating uncertainty into the mapping process itself. Uncertainty is a key feature of emerging technology and an important aspect that must be considered when developing policy for new technologies (McAslan, et al., 2024). We do this by adding 'error' bars to each policy event. We therefore consider if a policy event would have more potential impact towards success or failure for both public values and market values. We also weigh the public values against the market values in identifying the direction of the 'error'. If the error bar is horizonal, this reflects greater uncertainty on the market value axis, whereas if the error bar is vertical, we evaluate the event to have a greater amount of uncertainty for public values. In practice, this means that if a policy event has a high degree of public value uncertainty, then the event provides more benefit to market values and the degree to which is may also provide public value presently unknown. We assess if an event has more market value or public value in conjunction with the mapping process itself.

To demonstrate how this works further, consider the following example. In the case of AVs, the benefits (or risks) of AVs are widely unknown, and research shows they could be very positive or very negative in terms of environmental, land use, or mobility impacts, depending on how they are deployed. AVs are anticipated to be more beneficial if they are shared rather than private, thus the introduction of an AV ridesharing service might be expected to have more positive impact towards public values but could also lead to public failure if congestion increases, for example. Thus, we show a large 'error' bar indicating this large uncertainty. The deployment of Waymo One marked a clear market success where policy enabled Waymo to begin commercial services in the Phoenix area. In contrast, a policy event with a smaller error bar indicates an amount of certainty that is less than other events. The error bars do not measure a certain amount of uncertainty but the degree of uncertainty relative to other policy events that we include in the public value mapping.

5. Public value mapping in smart cities

Since PVM is not a decision-making tool, but one that can promote deliberation about public values, we argue that it can help cities in public engagements processes for smart cities and smart city technology projects. It is a model that aids in navigating complex tensions between market value and public value. Since the smart city has largely been characterized by values related to economic development, optimization, and efficiency, there is a pressing need for identifying, re-evaluating, and reassessing how emerging smart technologies can aid cities in supporting the public goals they aim to (Powell, 2021).

Research linking smart cities and public values are infrequent and there is a clear gap in the literature. Meijer et al. (2016), for example, argue that a contextual understanding of the conditions, governance models, and assessment of public value is important for realistic smart city strategies but interpret public value in the smart city in terms of performance, when a smart city "does well". Although they contribute to the discussion of smart cities and public value, they do so in terms of the market. We instead seek to explore how this happens in tension with more dominant market values. PVM allows us to consider this while also demonstrating how it can be used in practice by urban policy makers in need of new technology assessment tools.

In this section, we explore two technologies – autonomous vehicles and facial recognition – and how the different approaches taken (e.g., outcomes, use of technology, policy actions, etc.) can result in different outcomes on the market / public, success / failure continuum. We examine different sources to locate broad public values and how they apply to the specific cases we examine. In Tempe, we draw on the Tempe.gov website, the City of Tempe General Plan 2040, the Tempe City Council Strategic Priorities and Performance Measures and other similar documents. In Portland, we draw on the Portland.gov website, the Portland 2035 Comprehensive Plan, SmartCityPDX goals and mission, and other similar documents. In addition, we use public documents detailing discussions of AVs and FRT, respectively, or emerging technology more broadly. We also draw on news and media about these technologies, as well as other relevant documents, such as the State of Arizona Executive Orders pertaining to operation and testing of AVs. Also incorporated into the mapping is a certain degree of subjectivity, which is both a strength and weakness of the method. We draw on broader literature about public values and emerging technologies to inform our assessment of how to 'map' the different events or stages in each case study.

5.1. Autonomous vehicles: mobility boom or bust?

Autonomous vehicles (AVs) have seen significant developments in recent years, with numerous automotive and technology companies developing and testing the technology (Singh & Saini, 2021) and cities and transit agencies piloting AV technologies (Haque & Brakewood, 2020). Pilot projects have developed out of growing hype for the technology, despite numerous setbacks and delays of anticipated deployment timelines (Boudaway, 2021). AVs offer numerous benefits, but also bring many risks. Cities may experience more congestion, more sprawl, more traffic, a decrease in public transit use, and other impacts that would negatively impact sustainability and equity.

Engineers, urban planners, and technology companies all promote AV technology for its potential to save lives and reduce congestion, but there is little agreement about the full range of potential benefits of the technology. The companies developing the technology, for example, tout its potential to reduce congestion, but research shows that this isn't guaranteed and that vehicle miles traveled (VMT) is likely to increase (Cohen & Cavoli, 2019). Other purported benefits, such as AVs increasing accessibility, supplementing public transportation, reducing greenhouse gas emissions, or a reduction in required parking (and associated land use benefits) are unlikely without intentional policy that will enable then, as an increasing number of critics point out (Cohen, Stilgoe, & Cavoli, 2018; McAslan, Najar Arevalo, et al., 2021; Stilgoe, 2018).

Many urban planners working in municipalities recognize the need to plan proactively, but remain uncertain how to proceed (Freemark, Hudson, & Zhao, 2020). However, numerous cities and regions in the U.S. have begun to develop policy initiatives to guide the deployment of autonomous vehicles, such as Pittsburgh's 'Shared and Autonomous Mobility Principles (City of Pittsburgh, 2019), the Seattle *New Mobility Playbook* (SDOT, 2017), and the Austin Smart Mobility Roadmap (City of Austin, 2017). Additionally, Metropolitan Planning Organizations (MPOs) have begun to develop policies around infrastructure investment and maintenance, ensuring safety, enhancing public transit ridership and developing multi-modal transportation systems that utilize AVs (McAslan, Gabriele, & Miller, 2021). And increasingly, cities and transit agencies are partnering with the AV industry to test the technology on public roadways.

There remains a lot of uncertainty about what the actual impacts will be of autonomous vehicles and so the extent to which the benefits – or public value – may be maximized remains unclear. But there is general agreement that without proactive steps in the form of federal, state, and local policy and regulation to guide the development of AVs, it is likely that the market values will outweigh the public benefits.

5.1.1. AV pilot projects and public value in Phoenix region

In August 2015, Arizona Governor Doug Ducey signed an executive order permitting the testing of AVs on public roads in Arizona (State of Arizona, 2015). While some public values, such as economic development and job growth, were clear in the Executive Order, there was less attention given to how safety would be ensured or how AVs might provide transportation access to underserved communities. AV companies were enticed to come to Arizona due to the 'hands off' regulatory approach. Google began testing their self-driving cars in Chandler, Arizona and in February 2017, Uber began testing their own self-driving vehicles in Tempe, Arizona. Many local leaders and policymakers viewed AVs as a symbol of innovation and a potential solution to many of the automobile and pedestrian safety issues that plague Arizona roadways.

On March 18, 2018, Elaine Herzberg, a pedestrian walking with her bicycle, was struck and killed by an Uber AV in Tempe. This marked the first fatality from an AV collision. While it would take some time for the National Transportation Safety Board (NTSB) investigation of the collision to conclude (which ultimately put blame on all parties involved – Uber, the safety driver, and the Arizona Department of Transportation (NTSB, 2019)), the response in Arizona was quick. Governor Ducey suspended Uber's operations in Arizona and updated his executive order on AVs to require companies to comply with all state and federal safety standards (State of Arizona, 2018), although no new additional safety standards were developed for AVs. The collision did not lead to deeper questions about the potential public values and potential public failures of AVs.

While these events were occurring, the City of Tempe convened a Technology and Innovation Subcommittee to explore how AVs might affect the city's strategic priorities. The committee chose to focus on Tempe's strategic goals as they had recently been developed through an internal city process and with community engagement to identify core public values and corresponding performance metrics to track progress towards these community goals. Table 1 identifies and defines Tempe's public values from their strategic priorities and shows how the purported benefits and risks of this emerging technology can contribute to the city's public values or not.

The key takeaway this case study provides is that the impact of AVs on each of these core public values was ambiguous. What the actual impact will be on Tempe's strategic goals and public values will depend on the policy and planning actions taken by the city and the actions of the AV industry in the region and how the technology delivers public values currently not fully addressed by other technologies. For example, AVs could support the development of 20-minute neighborhoods and enhance quality of life if the City of Tempe adopted policies that would encourage the deployment of AV shuttles to increase accessibility to the existing transit network. Alternatively, without coordination and planning, AVs could make single occupancy vehicles more convenient and disincentivize changes in the urban environment that would make neighborhoods more walkable, bikeable, and transit oriented or Avs without passengers could increase traffic congestion adding to the pre-existing traffic of vehicles with a human driver.

At the same time as Tempe was convening its Technology and Innovation Subcommittee, the City of Chandler began working with Waymo, which was testing their vehicles in a 50 square mile area (which also included parts of neighboring Tempe and Mesa). The city began a pilot using the Waymo One ride-hailing service (launched in December 2018) which allowed employees to use it to conduct city business instead of using a city-owned fleet vehicle. The goal was to see if this could increase productivity for city employees and reduce fleet maintenance costs. Waymo also began working with the Chandler Police Department and Chandler Fire Department to develop an emergency management training program so that first responders would have the necessary knowledge of how to interact with these vehicles under various circumstances (e.g., road detours, traffic violations, and collisions).

In mid-2018, Waymo and Valley Metro, the regional transit agency, announced a partnership to pilot and test using self-driving vehicles to supplement public transit services (Valley Metro, 2018). This partnership initially provided first/last mile transportation for Valley Metro employees and in phase two, the project used Waymo self-driving vehicles to provide rides to current paratransit subscribers living within the Waymo service area. These projects both demonstrate a willingness and interest of multiple actors in experimentation and learning, as well as the use of city-industry partnerships. These are two vital ways to maximize both public values and market values.

Table 1
Tempe public values from *Tempe City Council Strategic Priorities* and associated potential benefits and risks of autonomous vehicle technology in relation to these public values.

Public values	Definition of public values	Benefits of AVs	Risks of AVs
1. Public safety	Ensure a safe and secure community with commitment to public safety and social justice.	Could increase traffic safety and reduce fatal crashes and injuries from motor vehicles.	Could increase injuries and fatalities for pedestrians and cyclists.
2. Government openness and transparency	Support strong connections to the community by emphasizing the importance of open government, customer service, and communication.	Could increase access for those with mobility impairments to public meetings and broader civic engagement.	Private use of AVs would likely result in a similar situation to today, where many people do not have the ability to participate in civic engagement.
3. Quality of life	Enhance quality of life for all residents by investing in neighborhoods, parks, human services, amenities, with an emphasis on equity and diversity.	Could improve accessibility to parks, services, amenities, etc. for those with mobility impairments and those without driver's licenses.	Private use of AVs could worsen accessibility and increase the costs associated with accessing parks, services, and amenities. Could increase noise pollution in high traffic corridors.
4. Environmental sustainability	Implement sustainable growth strategies through long-term generational investments in technology, infrastructure, and public transit that contribute to safe, clean, healthy city.	Could promote sustainable development if used in public transit model which could encourage more dense urban development.	Could encourage more urban sprawl in the Phoenix region and reduce the demand for high density and accessible urban development in Tempe.
5. Economic vitality	Build economic stability and vitality by focusing on economic development, business development and retention, and creating a diverse economic base.	Could promote new business opportunities in mobility, improve accessibility, and reduce the transportation costs for households and businesses.	Cost of transportation could increase with AV technology, thus increasing transport costs.

5.1.2. Mapping public value of self-driving vehicles

The case of AVs in the Tempe and the Phoenix region show examples of how emerging technologies can either meet different public values (or not) at different points in time and how continued conversations about and engagement with an emerging technology can potentially contribute to public values and market values simultaneously. In the first stage of this case study, we map the first Arizona Executive Order, the purpose of which is recognized to be for economic development. While a public value itself, it does not contribute to broader considerations of public values, such as accessibility, sustainability, equity, safety, or others. In its narrow scope, we place this as a market success, since it offered little to no oversight of AV companies that might come to Arizona. At the same time, its narrow focus on economic development places it as a public values failure.

In the next stage, the 2018 pedestrian fatality is both a market failure and a public values failure. This event demonstrated that without oversight, the AV industry cut corners in their testing methods, resulting in the crash. As a result, trust in the AV industry was damaged and many cities outside Arizona adopted stricter rules for testing. Similarly, the crash signified a public values failure in that the established framework for testing AVs did not place enough emphasis on safety and oversight.

In response to the lack of state oversight, the Tempe Technology and Innovation Subcommittee set to work to explore the impacts of AVs in Tempe in relation to their strategic goals. This demonstrates a commitment to ensuring the technology would somehow benefit the city. However, the degree to which this might happen is highly uncertain. We thus map this as a public value success and a market failure since it is in response to growing concerns about the state of the industry and later (partly) in response to the pedestrian fatality.

Following the pedestrian fatality, the revised Executive Order outlined new rules for AV companies, while still lacking oversight. We see this as being a less strong case of a market success, as well as being more of a public value success. However, we also see more uncertainty around this executive order due to uncertainty around how public values might be supported or achieved.

In 2018, Waymo launched its ridesharing services, Waymo One. We place this as a strong market success, but neutral regarding public value. Additionally, we map this as having a very high degree of uncertainty in terms of how the deployment of this service would contribute to public values in Tempe and the Phoenix region. Following its launch, Waymo also began various partnerships with the public sector – with the City of Chandler and with Valley Metro transit agency. These partnerships show a willingness on the part of the company to work with the public sector to see if and how their service could contribute more to various public goals. We see this as happening, in part, as a response to growing skepticism of the AV industry, placing it lower on the market success scale. At the same time, it shows a slight shift in terms of public benefit, through the direct activities engaged in, as well as a general willingness to partner to provide public benefits and market benefits simultaneously. We map the uncertainty here on the market axis since there is arguably more uncertainty about how public-private partnerships provide market benefits over public benefits (Fig. 1).

In summary, the case of AVs in Tempe and the Phoenix region demonstrates an evolution in thinking about what public values and benefits should be most relevant to the deployment and testing of this technology. We see a shift from economic development to broader considerations about safety, equity, and sustainability. Additionally, we observed two extremes in this case. On the one hand, we see what can happen when there is little to no government action and industry actors fail to deliver on their own promises.

In contrast, we also see a willingness to develop partnerships, which could provide a pathway to increasing both market values and public values and placing them in less opposition to each other in the Phoenix region. Importantly, this case also highlights that these types of partnerships can provide both public value and market value without developing robust regulatory environments, which many view as a hindrance to innovation. The City of Tempe as well as other municipalities can leverage public value mapping as they carry out other urban assessments procedures, or amendments to the council's strategic priorities occur and new technologies arrive. The mapping of market and public values can be executed with an emerging technology and with an already existing technology to be compared as well.

5.2. Case 2: facial recognition – seeing eye-to-eye?

Facial recognition technology (FRT) is a biometric technology used to identify or verify the identity of an individual using their face and facial features as captured in photos and video using algorithmic processing (Li, Mu, Li, & Peng, 2020). FRT is used by many national governments for border control and crime prevention and is widespread in

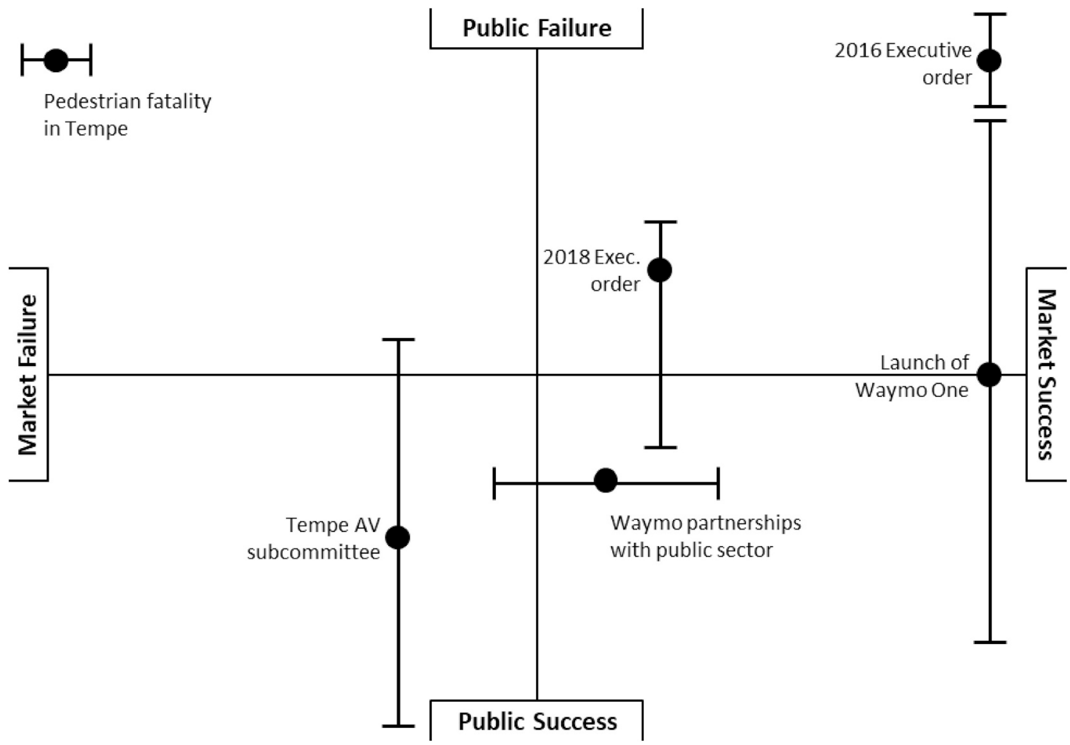

Fig. 1. Public value map of autonomous vehicles in the Phoenix region.

urban areas throughout the world (Curran & Smart, 2021). Supporters argue that FRT helps law enforcement agencies to identify criminal suspects, thus contributing to public safety. However, there is an increasing market for FRT, including general security (e.g., smart phone face identification), in banking for the authorization of payments, the tracking and monitoring attendance of students in schools, employees in the workplace, or those attending events (GAO, 2020).

FRT has drawn criticism stemming from algorithmic biases that further marginalizes minority groups and exacerbates racial and gender discrimination. This is because FRT systems have embedded bias in their coding and are not value neutral technological systems (Benjamin, 2019). Systems using predictive algorithms import biases from the systems they were built on, which reinforces existing unjust systems (Eubanks, 2019; Noble, 2018; O'Malley & Smith, 2022). For FRT, the GAO (2020) notes that while accuracy has increased in recent years, differences in performance still exist for certain demographic groups. For example, a National Institute for Standards and Technology (NIST) (2019) study found that some FRT systems are up to 100 times more likely to misidentify African American and Asian faces.

Misidentification can lead to the criminalization of certain minorities and reinforce existing racial profiling and reinforcing stigmas. The first known misidentification and wrongful arrest resulting from the use of FRT was of an African American man in Detroit in January 2020, based on video footage of an October 2018 shoplifting. Ultimately, a review of the investigative process found lack of controls in the process and loose standards for identification to be at fault (Geraghty, 2021) and resulted in the Detroit Police Department updating their facial recognition policies, which now forbids the use of the technology for surveillance and predictive analysis.

In the wake of this incident, in 2020, the American Civil Liberties Union (ACLU) and the MIT Algorithmic Justice League worked to spread awareness on the dangers of FRT. A National League of Cities report (Geraghty, 2021) identifies benefits and risks of FRT and offered practical guidelines for cities and possible regulatory approaches. Ultimately, "the emergence of facial recognition technology requires local governments to think carefully about the balance of privacy and transparency – along with the racial, gender and age bias in the data sets on which they are trained" (Geraghty, 2021). To this end, many cities, including Oakland and San Francisco, CA, and Somerville, MA banned the public use of FRT to protect civil liberties. Other cities still using FRT implicitly place more public value on public safety. With FRT, we see just how important it is for cities to assess the ability of these technologies to support public values and how to govern them effectively to reflect the needs of the community.

5.2.1. *Facial recognition in Portland*

Portland's experience with FRT is embedded in the social and political realities of social equity and impacted by the national debates surrounding FRT. Portland has a long history of civic and community engagement for the city's decision-making processes and has been a pioneer when it comes to smart city development. The City of Portland's smart city efforts are coordinated by Smart City PDX, which was established in 2018 to "address inequalities and disparities using data and investing in technology-driven practices that improve people's lives" (Smart City PDX, 2021). Smart City PDX, which sits within the City of Portland Bureau of Planning and Sustainability, sets priorities for smart city policies and technologies with a focus on civic engagement with underrepresented groups and underserved communities. In 2019, the office developed a set of guiding principles that focus on equity and privacy and consist of the Priorities Framework and the Privacy and Information Protection Principles (PIPP). The Priorities Framework outlines a process to guide decision making by city staff about data collection and technology investments (Smart City PDX, 2020b). The PIPP provides guidelines to protect sensitive data by focusing on transparency and stewardship, full lifecycle stewardship, equitable data management, non-discriminatory use of data, data openness, automated decision systems, and data utility (Smart City PDX, 2020a).

Increasing concern about privacy and technology bias from communities of color and other marginalized groups led Smart City PDX to engage with these groups to discuss the use of FRT in Portland. Privacy advocates indicated the process showed Smart City PDX's commitment to listening to community concerns (Simonite, 2020) and through this public engagement process, a set of public values was identified that pointed to favoring a ban on the technology, reflecting the concerns of the community. Local leaders voiced concern about the use of FRT cameras at Jacksons Food Stores in early 2020, which were intended to improve safety and reduce thefts (Kaye, 2020). Additionally, African American residents raised concerns about FRT being less accurate for people with darker skin, which reflected academic discussions about FRT and the misidentification of individuals due to their race, ethnicity, and gender (Buolamwini & Gebru, 2018).

In Fall 2019, Smart City PDX released draft legislation which then went through multiple stages of public engagement. An important step in this process was a City Council Working Session in which the City Council, together with city staff and members of the public, discussed the proposed FRT ban. In September 2020, the Portland City Council voted unanimously to ban FRT use by the city itself and by private entities in places of public accommodation, including public spaces, stores, sports venues, etc. While other cities had banned municipal use of FRT, the Portland ban went further to reflect its own communities' concerns over the possible widespread use of FRT. In the Press Release announcing the ban, Portland Mayor Ted Wheeler said that "we must protect the privacy of Portland's residents and visitors, first and foremost. These ordinances are necessary until we see more responsible development of technologies that do not discriminate against Black, Indigenous and other people of color" (City of Portland, 2020) (Table 2).

In Fall 2021, Smart City PDX launched a community engagement process to develop a comprehensive surveillance technologies policy (Smart City PDX, 2022). While the use of FRT is considered within this policy, it does not necessarily address the use of other technologies. In February 2023, the Portland City Council adopted Resolution 37,608 which directs the Bureau of Planning and Sustainability, Smart City PDX and the Office of Equity and Human Rights to design and implement a surveillance technology inventory and to develop strategies and procedures for the use and acquisition of surveillance technologies (City of Portland, 2023). Additionally, it requires the use of Privacy Impact Assessments for use and procurement of surveillance technologies. The adoption of these new policies demonstrates an ongoing commitment in Portland to continue a dialogue with residents to identify and embed public values in their policies for emerging technologies.

5.2.2. *Mapping public value in facial recognition technologies*

In mapping the events and actions leading up to and following the FRT ban in Portland, we draw from the public values outlined by the City of Portland in various documents, including the Smart City PDX guiding principles, City Council resolutions, and the 2035 Comprehensive Plan to consider how FRT contributes to and reduced public value. Front and center in the Portland case is a strong commitment to social equity and justice. While a long-standing goal, this is reiterated within the smart city office, which aims to ensure that data and technology meet the needs of the community and to prioritize projects that reduce existing inequities, particularly people of color and people with disabilities. In this way, Smart City PDX directly ties the city's public values to emerging technology in the city. In contrast to the Tempe/Phoenix case, where public values were adapted as circumstances changed, the Portland case shows a concrete public value and how policies and actions were a result of the strong articulation of these public values. Further, the Portland case illustrates how a city can adapt to new circumstances while also ensuring that its public values are upheld.

On the public value map (Fig. 2), we see the purported public safety benefits of FRT, which we have mapped as a market success and small public success. Importantly here, we show a significant amount of uncertainty in terms of what the actual public benefits or values may be, particularly when considering its use in an urban context or by a city government. At the near opposite spectrum, we map the misidentification and arrests of individuals (e.g., the case in Detroit) as both a public values and market values failure. This event, and other similar events, show that there are significant risks to using the technology in local

Table 2
Portland public values from *City of Portland Core Values* (2020) and associated potential benefits and risks of facial recognition technologies in relation to these public values. For full text of the core values, see Resolution 37,492, adopted in 2020.

Public values	Definition of public values	Benefits of FRT	Risks of FRT
1. Anti-racism	The City of Portland is an anti-racist institution… Racism, discrimination, and bias are not tolerated within the workplace or in our communities… The City of Portland condemns oppression, violence, and hate speech toward people of color.	FRT could identify individuals who commit crimes driven by racism and discrimination.	FRT has been called out for the misidentification of people of color as potential crime suspects. FRT has been identified as a tool that enhances existing racial profiling in prosecution.
2. Equity	We value the intersectional identities and lived experiences of our workforce and over 650,000 residents… Equity, access, and the removal of institutional and systemic barriers to resources and opportunities are essential in diversifying our workforce and the public good.	Face photo banks could help to develop a more efficient e-government experience which could save time for residents in certain services or to identify vulnerable residents with the most pressing needs of services.	The use of FRT could result in increased levels of racial bias. Gender bias is another documented risk of FRT. Together these would reduce the ability of FRT to contribute to more equity.
3. Transparency	Transparency is essential to upholding the principles of democracy… We establish and maintain trust through integrity and intentional inclusion.	Can be used within in combination with public health databases to protect the public in extreme situations (e.g. COVID contact tracing).	The use of FRT in any public space prevents people from consenting to its use. Current use of FRT is not transparent since individuals do not know how data is used, managed, and shared with other parties.
4. Communication	Communication serves as a catalyst for transformative change… Knowledge sharing impacts our workplace and communities.	FRT could enable targeted communication to different people based on their own preferences.	FRT could further worsen how knowledge is shared and communicated and further marginalize communities of color.
5. Collaboration	Civic engagement and receptive collective action empower our employees and residents… Inclusive outreach and public engagement increase institutional	FRT could be used to aid in collecting data on what communities the city is engaging with and which communities it is not by identifying participants in public	FRT could further exclude people from participating in civic engagement who wish to do so in more anonymous ways.

(*continued on next page*)

Table 2 (*continued*)

Public values	Definition of public values	Benefits of FRT	Risks of FRT
	knowledge and awareness.	participation events.	
6. Fiscal Responsibility	Every budget decision focuses on fiscal resiliency, climate action, equity, and the needs of our most vulnerable populations.	Could help the city more effectively enable vulnerable populations to receive the services they need and budget accordingly.	Could reinforce existing disparities between where city services are provided and how they are budgeted for.

policing. Specific to the public values in Portland surrounding equity and social justice, these arrests and false identifications are antithetical to the city's goal of promoting equity and reducing racial disparities.

The potential negative impacts towards the public values of Portland spurred community activism, which led directly to the city's FRT ban. We map this as a significant public success, and a significant market failure since the city and its residents implemented the ban due to a lack of trust in FRT to ensure equity and justice. This contrasts with other cities that only implemented public FRT bans, which are less severe market failures and arguably less significant public successes since there is still risk that private uses of FRT would result in racial inequities in Portland.

Most recently, the City of Portland has engaged in a more robust public engagement process that is attempting to understand the rightful place of advanced surveillance technologies in the city. This is in large response from the business community that the municipal and private sector ban was too much and that this blanket ban prevented beneficial uses of FRT, thus potentially preventing any public benefit from its use, as well as limiting any private sector benefits. We map this process and the resulting Surveillance Technology resolution as a public value success as it demonstrates the city's commitment to ensuring that any future use of FRT or other surveillance technologies uphold the public values of Portland and prevent negative outcomes, particularly with regards to privacy, as reflected in the push to use Privacy Impact Assessments. We also note that there is a high degree of uncertainty in terms of the market value impact of this process since it could significantly allow the private sector to use FRT in certain use cases. While the private sector mostly pushed for this process and lifting the ban, the extent to which they can gain more market value from FRT or other surveillance technologies is still unclear.

The public values we identify in this case place an emphasis on privacy protection and community engagement with groups that are usually underrepresented and left out of decision-making processes. By doing this, Portland ensures that BIPOC communities that experience the biases of FRT are fully involved in the process of governing the technology. The City of Portland examined carefully through multiple rounds of community engagement what public values were leveraged with this emerging technology. The FRT ban along with current work on the Surveillance Technologies Policy and the new requirements of Privacy Impact Assessments for any surveillance technologies demonstrates the city's anticipatory capacity (Sarewitz, 2011) as well as recognizing that the risks of the technology would not be borne equally. While possible socially beneficial uses of FRT exist, the Portland community shows it was is not willing to have an experience like the one in Detroit. Protecting civil liberties, protecting privacy, and listening to concerns about injustices are public values that outweigh others.

6. Discussion

The question of the public values of emerging technologies is a pressing concern for local, state, and national governments. In both cases discussed in this paper – autonomous vehicles and facial recognition technology – the municipalities involved deliberated in very different ways about the role of new technologies and how they might meet different goals associated with different public values. In Portland, the city listened to community groups' concerns about the risks to privacy and surveillance that are embedded in facial recognition technologies. In Tempe, the city sought to understand better how AVs could help them achieve certain goals, including them as a possible way to reduce climate emissions in the 2020 climate action plan. Chandler and Valley Metro partnered with an AV company to deliver public benefit.

These two cases represent very different approaches to achieving public value and planning for emerging smart city technologies.

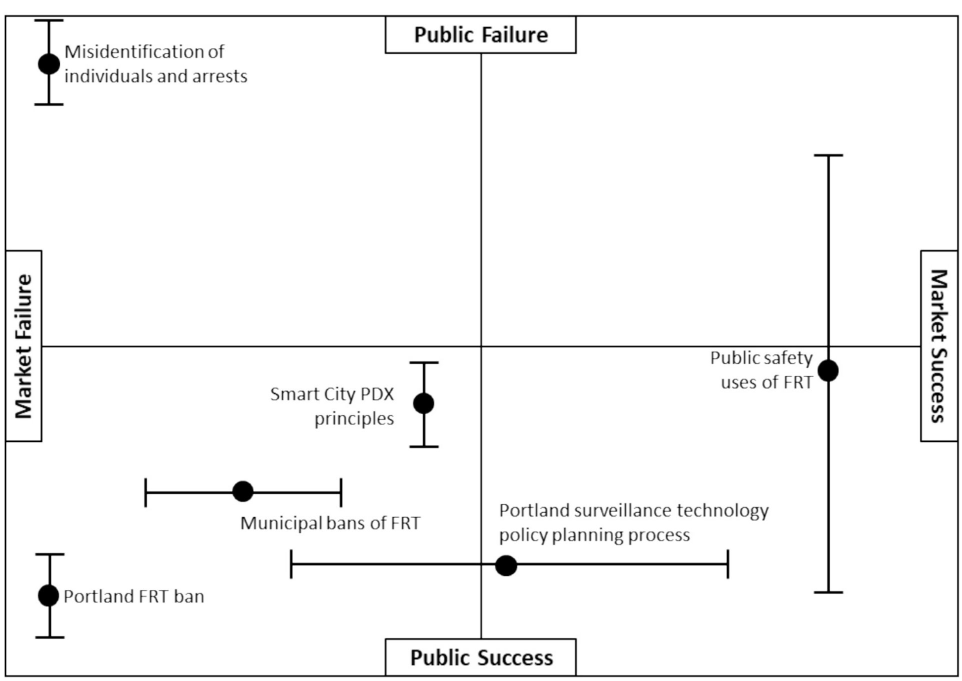

Fig. 2. Public value mapping of facial recognition technology in Portland, OR.

Portland's ban on FRT is a response to a market failure on the part of the smart city industry to address the needs and concerns of different communities the technology impacted negatively. Drawing on growing evidence of smart city projects gone wrong, Portland decided to alter course to ensure that equity and public engagement were central to their smart city efforts. In the case of FRT, this meant that the potential risks, which had not yet been experienced in Portland, outweighed any benefits, such as uses within public safety. Because Portland had already created a policy context in which equity and engagement were key, when community groups voiced concern about the increasing risks of FRT, the city acted. Now, within that same policy context, Portlanders are considering the broader role of surveillance technologies in their communities, a process that may duplicate similar public values that became evident in the FRT ban or new public values that will shift new policy more towards a model of achieving both public value and market value. This case demonstrates how smart city technologies that are pitched as smart solutions by industry, imminent unstoppable technologies by techno-determinists, can take a different course when these technologies are questioned in terms of public values.

In the Phoenix region, we see a different approach and a different outcome, where public values and market values are more likely to be addressed by the work municipalities are doing. While the initial policy context was one that very much indicated a market success over certain public values, multiple jurisdictions have developed partnerships with AV companies to see how they may work together to gain public value. Partnerships developed between Chandler and Waymo and Valley Metro and Waymo show how this process can provide public value while not reducing market value. However, in a broader policy context that does not aim to ensure public values are achieved, this outcome is not guaranteed, and situations can arise that stand in stark contrast where both public failure and market failure occur, as happened with the pedestrian fatality in Tempe. Responses to this have attempted to reassert the need for public value to be a central part of the deployment of this technology.

Both cases show the challenges of attempting to guide emerging technologies along pathways that can deliver public value. In each case, large uncertainties in the relationship between technology policy and implementation and public value benefits remain. For example, can AV companies like Waymo work with Valley Metro and the City of Chandler in ways that might deliver public benefit but that would cut into market value? As a result, how much public value benefit is left uncaptured? Exploring these public-private partnerships with a PVM lens can help analyze the tensions and potential beneficial opportunities between the public and market values. The use of public private partnerships has been widely advocated for within smart city projects (Neuroni et al., 2019; Quan & Solheim, 2023), and PVM can further show where public benefits and market values align in these multi-sector partnerships.

The PVM literature has thus far been focused on retrospective cases to develop the public value framework (Bozeman, 2007; Bozeman & Sarewitz, 2005), large-scale analysis of federal science policy (Meyer, 2011) or more anticipatory cases, such as those related to nanotechnology. The cases developed here point to the ability of PVM to offer a tool to practitioners, decision-makers, and communities to develop a vocabulary and framework that can support the articulation of local, public values and how smart cities and emerging technologies can be deployed in ways that meet and advance those values. Our development of this framework here is admittedly limited in that it is analyzing these cases from afar and retrospectively. The next step in PVM should be to develop it as an engaged, real-time public value mapping and deliberation framework. As Bozeman (2007) notes, the potential in PVM is in the need for a counterweight to economic-centric policy analysis and to provide a space for the discussion of shared public values and goals. As communities reckon with issues from smart cities to climate change, an engaged PVM methodology and deliberation-support framework is critical to reorienting decisions to public values.

As smart city technologies are increasingly deployed, municipal governments have an important role to play in their development, particularly in the absence of state and local regulation. The corporate model of smart cities emphasizes the role of private companies and their push to develop new technologies in urban settings through real-world experimentation (Hollands, 2015; Miller, 2020; Sadowski & Bendor, 2019). A shift to a citizen-driven smart city has begun to occur (Cardullo & Kitchin, 2019a), with many cities pushing back against the corporate narrative and redefining the smart city for themselves, for example Toronto (Morgan & Webb, 2020) and Barcelona (March & Ribera-Fumaz, 2019). Cowley and Caprotti (2019), in their critique of smart cities, highlight a broader experimentalist turn in policy-making as a reason why they smart city has become a strong urban development narrative. They go on to argue that this experimentation trend can contribute to “constant adaptive learning within institutional processes once more explicitly guided by longer-term envisioning of the ‘public good’ and the aspiration of mitigating public bads” (Cowley & Caprotti, 2019, p. 15).

These critiques of corporate-driven smart cities echo Bozeman's (2007) critique of new public management, in which public policies, design, and evaluation are based on market theories. Bozeman's ‘managing publicness’ critiques the applicability of markets to government decision making. The application of market theories to public policy is not unlike the current trend of smart cities to depoliticize urban decision making through techno-solutionism. Both aim to simplify complex urban challenges by reducing them to seemingly less complex economic or technological challenges. Both approaches lead to decision making that is driven by data rather than public values. While some municipalities have begun to reassert their public values in response to the possible risks of emerging technologies, they have few tools to consider how to evaluate potential benefits and risks of new technologies.

Public value mapping emerges as one possible tool to aid policy makers and urban decision making by weighing the market benefits against the public benefits of any given technology. The cases discussed in this paper – autonomous vehicles in Phoenix and facial recognition technology in Portland – demonstrate how PVM can be used in practice. A first step for many municipalities, however, is to formulate the public values against which new and emerging technologies can be evaluated. Next, they must evaluate the benefits and risks of emerging technologies in relation to these public values. Then planners and policy makers can ‘map’ different actions they have already taken – or plan on taking – and engage in a dialogue with relevant stakeholders, such as technology companies, elected official, community groups, or the broader public, to weigh public values against market benefits.

There is also relevance and potential of PVM for city governments to integrate into their already existing civic and public engagement efforts with low impact and budgetary changes in what they already do in this dimension. We also see PVM complementing other emerging approaches to address uncertainty and incorporate broad perspectives in policy development, such as policy co-design, data care, middle-out design, and adaptive planning (Blomkamp, 2018; Foth, Anastasiu, Mann, & Mitchell, 2021; Fredericks, Caldwell, Foth, & Tomitsch, 2019; Lewis, McGann, & Blomkamp, 2020; McAslan et al., 2024).

While smart city technology companies clearly express the nature of the solutions they offer and sell, PVM can help city governments map what the relevant issues, needs, community goals are and frame problems in their own terms and assess if a match exists with a specific smart city technology. Although the cases we present are limited to the U.S., the potential can be re adapted to smart city technology assessment in real-world policy in any urban context globally, given the widespread adoption of smart city model. In the ways we demonstrate with the two case studies, this approach can help minimize ideological mismatch (Lodato & DiSalvo, 2018) in the deployment of emerging technologies.

While PVM is a potentially beneficial tool for policy makers, it is not without limitations. Fukumoto and Bozeman (2019) identify three limitations of PVM: the identification problem, the motivation problem and the instrumentation problem. The identification problem addresses the challenge of defining public values and whether they can realistically be identified from a myriad of government documents and other resources and with the abstract nature of what public values are. Even if imperfect, we might argue that these are at least a good starting point to counter those values espoused by smart cities discourse, which values technological solutions, efficiency, and innovation over values such as equity or inclusion. We have also taken care to only use public values that have emerged from participatory processes for our analyses. More robust approaches to incorporating PVM into policy making can use it directly in public engagement and procurement efforts when considering a potential smart city partnership.

In the case of Portland, it was precisely the role of civic action that led to policy changes that are now reflected in the policy documents we use in our analysis. Mann et al. (2020) show that in Toronto and Barcelona, the inclusion of residents in assessing what technologies they do want and do not want for their city resulted in the development of public values around technological sovereignty, social license to operate, and future decisions. These emphasize that autonomy in decision making in the context of smart cities is a shared social norm, as opposed to the top-down corporate smart city model of technology adoption (Miller, 2020; Sadowski & Bendor, 2019).

The second limitation Fukumoto and Bozeman (2019) detail is the motivation problem. This refers to the motivation to pursue PVM and whether it is done out of genuine regard for the public interest or for other self-serving motivations. This limitation is not unique to public values or PVM. This highlights the need for open and transparent processes in smart cities, that reduce the possibility for corporate control of the process – as happened in Sidewalk Labs Toronto (Filion et al., 2023; Goodman & Powles, 2019). While many smart city projects now aim to be more focused on participation, Cardullo and Kitchin (2019b) show that smart urbanism is still rooted in "pragmatic, instrumental and paternalistic discourses and practices rather than those of social rights, political citizenship, and the common good" (p.813). In this way, participation in smart cities is often more tokenism rather than meaningful engagement (Dobson & Parker, 2023; Kamols et al., 2021; Monno & Khakee, 2012).

The third limitation Fukumoto and Bozeman (2019) describe is the instrumentation problem, referring to the development of 'appropriate and effective instrumentation and implementation'. They argue that the same public values can be identified with different instruments that focus on different aspects of public values. They also discuss how the realization of public values does not happen at once but is an ongoing process. As with urban development processes within the smart city, no single technology will define the smart city, but it is instead the culmination of many technologies and the policies that dictate and direct their use. It is important to recognize that as time goes on, public values shift, and that the technologies we deploy in our cities need to be responsive to these shifts. Similarly, public policy must respond to these shifts in values and in technology. The value of PVM is in its flexibility and adaptability to different situations and contexts, from small scale technology deployments to broader societal impacts.

7. Conclusion

This article has shown that public value mapping can be a useful tool for researchers and city staff to assess how the vast array of new technologies being promoted as smart city solutions can offer public value. Recalling that "public values, or those societal aspirations not easily defined in economic terms, enter into many aspects of science and innovation policy development and implementation" (Slade, 2010, p. 2), we see that there is a strong need for new frameworks to assess emerging technologies. Public value mapping provides such a framework to assess and deliberate on the public values of emerging technologies by asking questions that might not arise in more traditional environmental assessments, cost benefit assessments, or any other impact assessments grounded in economics (Fisher et al., 2010). PVM can help cities that are developing smart city plans to identify public values and use this information in their decision-making processes.

Our aim has been to develop a process that policy makers can use to evaluate emerging technologies. To achieve this, we have applied public value mapping to the case studies of autonomous vehicles in the Phoenix region and facial recognition technology in Portland to demonstrate how PVM can be used. We identified key 'policy events' which have been important lynchpins in both deployment of the technologies and in their regulation in their respective region. As more smart city technologies are developed, this approach of adapting PVM to an urban context can be further fine-tuned with more quantitative approaches than we have used here – an important role for research.

In this paper, we demonstrate how PVM can be used to 'map' policies and events related to an emerging technology. Through this exercise, urban planners and policy makers become aware of the possible implications of their actions and of the policies they may adopt. But ultimately, it is a tool that can be used to assess technological choices and does not tell policy makers how to act. PVM has also been critiqued for its reliance on normative expressions of values and the use of government documents as a methodological data sources (Fukumoto & Bozeman, 2019). This limitation highlights the need for using PVM alongside other policy making tools and within robust public engagement processes. PVM is not a replacement for, but a supplement to other commonly used policy tools, and can help balance out an over-reliance on tools like cost-benefit analysis.

This article adds to the literature that explores how to assess whether smart city projects and technologies provide public value. Through our two case studies, we show how different approaches and actions on emerging technologies show that it is possible to create both public values and market values, but also highlight when there are disparities and tensions between these values. Future research can also play a role in exploring how to use PVM within in a public participation process. Or researchers can engage more closely with cities to explore how PVM can help address knowledge gaps and lead to more informed policy development for smart city technologies. As next steps, we suggest the examination of other tools complimentary to PVM that can be applied in the operations city practitioners do daily when encountering opportunities to engage in partnerships with smart city industry.

CRediT authorship contribution statement

Farah Najar Arevalo: Formal analysis, Writing – review & editing, Conceptualization, Methodology, Writing – original draft. **Thaddeus R. Miller:** Methodology, Writing – review & editing, Conceptualization, Supervision. **Devon McAslan:** Formal analysis, Writing – review & editing, Writing – original draft.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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