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The Kind of Solution a Smart City Is

Knowledge Commons and Postindustrial Pittsburgh

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INTRODUCTION

Practice and writing about so-called smart cities often suffer from significant problems. This chapter aims to steer in a different and more productive direction.

First, the smart city, it is said, offers policy and practice challenges to those who would *create* the smart city in the twenty-first century (Green 2019; Luque-Ayala and Marvin 2020). The right view, instead, is to abandon the interest in *creation* and to hold to *evolution*, with "smart" systems affecting the character of cities in locally relevant ways rather than in the same ways in all places. Second, the smart city, it is said, "dematerializes" social, economic, and political relationships in cities, by abstracting human interactions in physical space, coding information into data, and using that data to unleash new potential for democracy (Goldsmith and Crawford 2014) or exploitation by elites (Morozov and Bria 2018). The right view, instead, is to see how the harms and benefits of information governance in smart cities is linked to physical infrastructures, both preexisting (buildings, roads, and open spaces, for example) and novel (wireless communications networks, for example). The right view sees city form and community participation patterns as descended from their pre-"smart" configurations, particularly in long-standing intersections between centralized control of urban planning and development, on the one hand, and grassroots, neighborhood-based, emergent patterns, on the other (Florida 2014; Glaeser 2012; Jacobs 1961).

Together, those corrections point to offering a portrait of smart city governance in historical, material, and social context that – to take the most optimistic view – enriches rather than limits conversations about the future roles of technology in cities. Smart cities are ripe for studies of multi-layered governance on a case-by-case basis, taking historical as well as technical, social, economic, and political contexts into account. Sweeping claims that condemn smart cities or that celebrate them are premature. Empirics matter. This chapter illustrates with a deep review of a

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mid-sized American city, one that both has experienced significant recent investments in smart technologies and also bears considerable scarring and rejuvenation in its recent "ordinary," non-"smart" development: Pittsburgh, Pennsylvania, USA. The chapter organizes its review via the Governing Knowledge Commons (GKC) research framework, because smart technologies in urban contexts prioritize questions about institutional governance of knowledge and information. Cities are both problem and solution. What kind of problem is the smart city? What kind of solution is it? In that spirit, the chapter's title borrows from the title of the concluding chapter in Jane Jacobs' *The Death and Life of Great American Cities* (Jacobs 1961; see also Bettencourt 2013; Hochfelder 2020). Pittsburgh's smart city experience is inescapably entwined with Pittsburgh's evolving industrial and postindustrial urban character.

The next section provides a brief introduction to Pittsburgh itself, drawing specific attention to features of the city's experience that I characterize as social dilemmas. These are the governance problems that are the starting points for knowledge commons research. A section on methods and key insights follows. Evidence takes up the next section; Pittsburgh is subjected to a deep review of its history as it relates to smart city practices, including data gathering and public administration and recent uses of ICTs. That leads to a section reviewing recent and contemporary smart city initiatives in Pittsburgh, both describing actors and motivators and listing them in tabular form. The chapter then sketches key implications and questions for further research. A brief conclusion uses the Pittsburgh case to ask about the future of the smart city, the future of the city, and the role of knowledge commons in understanding both.

THE CASE: PITTSBURGH

Today, Pittsburgh is a mid-sized American city, and the "mid-sized" characterization assumes that the population of the city proper (only about 300,000) is linked to the population of the surrounding region (roughly 2 million more, in total). For much of the twentieth century, Pittsburgh was a larger place in both respects, and the Pittsburgh region was a world-leading industrial center. Pittsburgh produced roughly one-quarter of the world's structural steel. In the early 1980s, for reasons that lie mostly beyond the scope of this chapter, that industry ended. As community and economy, a hollowed-out Pittsburgh staggered on, eventually grounding its economy on an evolving, fragile blend of professional services – university-based education and clinical healthcare, termed "eds and meds." In its more recent pivot to high technology and an "innovation economy" as a development and governance focus, Pittsburgh has emerged as an urban center that relies as heavily as any other on knowledge-sharing practices and principles. Sometimes that reliance is explicit; more often, it is implicit. This chapter documents both.

Pittsburgh is arguably one of the great twentieth-century urban success stories, but in the twenty-first century, Pittsburgh is unexceptional. That makes it a good case for

examining governance of smart city technology, because Pittsburgh is neither behind some imaginary urban technology curve nor ahead of it. Like many cities, it doesn't aspire to be celebrated as a "smart city"; instead, it merely hopes to do well, even to thrive. Pittsburgh has steadily accumulated and deployed a broad range of technology systems as part of its public administration practice, publicizing its advances as often and as much as it might. The case study documents what might be referred to as "ordinary" or "normal" governance of smart city technology and governance via smart city technology.

RESEARCH METHODS

The chapter offers a broad historical take on ICTs and smart technologies in Pittsburgh. It also dives more deeply into some specific examples. Its research and presentation are pluralistic in tone, style, and method.

The research was informed by the fact that I have lived and worked professionally in Pittsburgh for close to twenty-five years. During most of that time I have participated actively in public dialogues about the region's technology-based economy and public policies. In selecting documents to review and in arranging and conducting interviews, I contributed my own knowledge of key historical and contemporary events, figures, and practices. Every effort was made to achieve descriptive (i.e., historical and journalistic) completeness. (Historical data from prior to the twentieth century was obtained from key secondary sources documenting Pittsburgh's history.) In part because much of the relevant source material was published or produced while research for this chapter was ongoing, inevitably those efforts fell short.

In addition to my own knowledge of Pittsburgh practice, sources and methods consisted of:

1. Analysis of public-facing documents and other materials relating to development or uses of smart systems, civic technology, data-informed governance, and algorithms and/or data analytics in and around the City of Pittsburgh. That includes Allegheny County, of which Pittsburgh is a part. Those documents included reports, press releases, and summaries of public events and meetings and were published on public websites by public authorities, private actors working in concert or coordination with public authorities, and online news media. I selected, collected, and reviewed documents and materials for both critical developments and shared themes based on my preexisting knowledge of the practices of technology-focused economic development communities in Pittsburgh. In one instance of contemporary practice (Pittsburgh's 2020 contract to host its municipal data with Google Cloud), I obtained documents both via a formal Right to Know request under Pennsylvania law and via the City of Pittsburgh's public-facing procurement website, Beacon.

2. Semi-structured interviews conducted with participants in smart cities strategies and deployments in the City of Pittsburgh and Allegheny County. Some work in the public sector, some in the private sector, some in higher education, some in nonprofit organizations, and some in philanthropy. I completed nineteen interviews in all. Like the public materials, I selected interviewees based on my prior knowledge of the systems and structures that characterize the technology and economic development communities in Pittsburgh. They were chosen in part for their diversity of perspective and in part for their commonality of interest. The interviewees all have or have had active roles in developing Pittsburgh as a smart city. My direct connections to the subject matter of this chapter are disclosed below.

PITTSBURGH'S TWENTY-FIRST-CENTURY SOCIAL DILEMMAS

Much of the following narrative focuses on smart city practices in Pittsburgh in a specific time period – from 2014 to the end of 2021 – and in a specific environment, the City of Pittsburgh proper. That focus is based on the fact that much of Pittsburgh's contemporary smart city identity is grounded in the vision and practice of Mayor of Pittsburgh Bill Peduto, who took office in early 2014 and who exited, after two terms, at the end of 2021. This section lays the foundation for analysis of smart city governance by highlighting the social dilemmas, both conceptual and pragmatic, that confronted the incoming mayor in early 2014. The GKC framework calls for inventorying social dilemmas but does not require that this step be the first. In this case, it seems wise to begin with social dilemmas. With this inventory in hand, later sections explore relevant resources, action arenas, and smart city strategies, including the origins of those dilemmas; smart city practices and solutions that came before Mayor Peduto's tenure, and the contributions of other actors and organizations both before and during his service.

By "social dilemma," I mean a collective action or coordination problem, a possible conflict between the ends of individual behavior (individual welfare) and the performance of a group of people, acting as a social system (social welfare). The smart city context offers two broad types of social dilemma. The first consists of dilemmas created by the social, cultural, and economic conditions facing the city as a whole. Some of those involve knowledge and information; some do not. These are dilemmas to which smart city practices are believed to be solutions, wholly or partly, so that information governance is a means to the broader ends of urbanism. The second consists of dilemmas created by smart city practices themselves, so that the benefits and burdens of knowledge and data sharing require further additional layers of information governance.

Both kinds of dilemmas are summarized here. This section includes both a broad, macro view of the challenges that confronted Pittsburgh during Mayor Peduto's

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tenure and also mid-level (meso) and micro views of dilemmas specifically connected to the smart city. They are described in the present tense, because they continue to characterize the city.

Not all of these dilemmas directly implicated smart city practices, and not all of the smart city practices deployed in Pittsburgh were effective in dealing with these or other problems. But these were the background conditions that described Pittsburgh largely in advance of its significant investments in smart city technology.

Postindustrial Renewal and Economic Development

Pittsburgh's first key dilemma consists of how to modernize an old, industrial city, with old material infrastructures; a declining population; an irregular geography; social and political infrastructures anchored in old institutions; many small neighborhoods disconnected from political power; formal fragmentation of government authority; and little reliance on modern data-focused systems. That dilemma includes day-to-day questions involving city living and working for residents and larger-scale questions involving how to grow and diversify the region's economy, which is recovering from its former dependence on large-scale industrial manufacturing (Andes et al. 2017; Madison 2012). Pittsburgh was an industrial city and region almost without peer. Today, Pittsburgh is unambiguously a postindustrial city and region. But the meaning and practice of its postindustrial status is in the process of being built – politically, economically, socially, and technologically. Economic renewal efforts still dominate the region's political and cultural conversations roughly forty years after Pittsburgh's steel industry collapsed.

The durability of the need and the difficulty of finding solutions testify to the depths to which Pittsburgh's older industrial core shaped the region in every respect. It also testifies to the difficulty of marrying the legacy of that core to twenty-first-century technologies and governance. As Mayor Bill Peduto has said, smart city developments in Pittsburgh are linked closely to Pittsburgh's emerging postindustrial identity, and the success of the new strategies depends on building on that core, not distinguishing "new" Pittsburgh from "old" Pittsburgh (Peduto 2015).

Public Administration

A second key dilemma involves the role of governance itself. Pittsburgh has experienced a conversion, from ideas of good governance as a means to the end of shaping Pittsburgh to good governance as an end in itself. The former perspective is highlighted by the public–private partnership embodied in the original, mid-twentieth-century Allegheny Conference for Community Development, described in greater detail later. The latter is highlighted by the idea of data-driven public decision-making as a modern value, embodied in particular in the contemporary Allegheny County Data Warehouse.

Not only have the aims of good governance and data-based decision-making changed, but as with all purported ideological shifts, practice may not match rhetoric, exposing social dilemmas within social dilemmas. After 2014, the City of Pittsburgh's Department of Permits, Licensing, and Inspections was provided with digital technology for the first time with respect to many of its operations, both internal and public-facing. Snowplow operators and road repair crews were provided with tablet computers. Upgrades in the quality of service did not automatically follow. In part, legacy practices were simply difficult to dislodge, because incumbent staff members were comfortable with existing practices and were challenged by technology-based changes. In part, the material cost of technology outstripped the vision. The City of Pittsburgh circulated a call for proposals for smart street lights in 2018 relative to the city's 40,000 street fixtures. It was imagined that the lights could be used for a mesh network of public Wi-Fi, would integrate with smart traffic control technology, and would monitor local air quality. The project was abandoned when city administrators realized that the effort would require installing thousands of miles of new network cables. Some obstacles are bureaucratic or logistical. Pooling data of different types and from different sources in a fragmented system presents considerable bureaucratic, labor, and technical challenges as data are generated to meet the details of different technical specifications.

Historically Grounded Inequities

A third central dilemma concerns the lack of alignment between Pittsburgh's smart city goals and strategies with both community interests and research objectives at Pittsburgh's key partners in nearby universities. As to the community, the problems that the City of Pittsburgh has tried to solve with smart city technology are not necessarily the most significant community-based problems that need to be addressed. As to research alignment, the priorities of Metro21: Smart Cities Institute at Carnegie Mellon University (CMU), which coordinates much of the relationship between CMU researchers and the City of Pittsburgh, are heavily influenced by partnerships between the institute and private industry.

Like many American cities, Pittsburgh suffers from profound inequities across different city neighborhoods and between the City of Pittsburgh and communities nearby, in Allegheny County and beyond, in the delivery of and access to basic amenities of urban living: public transit, education, clinical health and public health, clean air, clean water, safety and security, and economic opportunities. Smart city strategies were undertaken in part to begin to address those problems, by expanding the populations of citizens who were engaged in governance and community-level decision-making. Again, social dilemmas emerged within social dilemmas; historically excluded communities were skeptical of government solutions anchored in contemporary ICTs. In accessing government services, for example, people preferred to interact with human beings rather than with machines.

Polycentricity

Pittsburgh's experience seems to teach the opposite of an important line of political science research that promotes polycentric order as an optimal governance strategy, if it aligns governance resources closely with relevant communities (Black 2008; Ostrom 2010). In Pittsburgh, smart city strategies both respond to and are frustrated by the region's host of fragmented and decentralized formal organizations and institutions. The region is rife with overlapping and intersecting jurisdictions, funding powers and responsibilities, and areas of cultural and persuasive authority.

This polycentric disorder is evident in Pittsburgh in at least two respects. Schematically, and recognizing that these two phenomena overlap considerably in practice, one is effectively horizontal and involves coordination among political, economic, and social or cultural leadership in different organizations. Two is effectively vertical and involves coordination between political, economic, and social or cultural leadership, on the one hand, and local communities and neighborhoods comprising the actual residents of the city, on the other. Governance mechanisms that address the former set of coordination challenges are comparatively numerous, well-structured, and well-documented. Governance mechanisms that address the latter set of coordination challenges are comparatively fewer in number and more difficult to detect and to study, particularly once one moves beyond formal systems of democratic participation, i.e., regular elections of public officials.

Political-Economic Hierarchy

Because Pittsburgh as a region is characterized by extreme formal fragmentation of political authority, overcoming obstacles and achieving coordination and cooperation among political organizations with respect to smart city practices is highly context-specific and often incomplete. Relevant mechanisms blend numerous formal and informal practices. In some smart city contexts, governance dilemmas focus on the privatization of public functions. That pattern is less pronounced in Pittsburgh. The relevant social dilemma focuses less on the role of private technology companies in dictating public policy and more on the ways in which public problems are solved by informal alliances of public, private, nonprofit, and philanthropic actors.

Some of the obstacles are budgetary. Until Mayor Peduto was inaugurated in 2014, the City of Pittsburgh Bureau of Police lacked any data analysts. Staffing has increased, modestly. Allegheny County, with greater financial resources and a significant track record in developing data analytics capabilities – funded initially by Pittsburgh philanthropy – provides voluntary data-related services and public-facing violent crime statistics dashboards for the City of Pittsburgh.

Some of the obstacles are jurisdictional and organizational. While Pittsburgh's Western Pennsylvania Regional Data Center (WPRDC) is designated by both the City of Pittsburgh and Allegheny County as their official open data repository, the

WPRDC has declined to accept and host certain datasets produced by the Allegheny County Data Warehouse, citing concerns that the Allegheny County data is not deidentified to the degree that the WPRDC and its other partners deem necessary. In 2021, the City of Pittsburgh launched a "Mobility as a Service" mobile application that integrates service data from the Port Authority of Allegheny County (an independent county-level entity that manages public transit services throughout the county, including the City of Pittsburgh) and private transit providers (technology companies offering ride-on-demand and carpooling services) with street-side access points and information hubs managed by the city.

Smart city strategies in these examples involve combinations of funding and relationship brokering that rely on third parties Neither the WPRDC nor the Allegheny County Data Warehouse would exist in their current forms today without substantial financial underwriting from Pittsburgh's large philanthropic community. Pittsburgh's Mobility as a Service initiative is funded by the Richard King Mellon Foundation. Many other smart city systems in Pittsburgh likewise rely on coordination among actors in the public sector and partners in Pittsburgh's university community. That coordination is often multisided and therefore fragile.

Socioeconomic Hierarchy

Despite's Pittsburgh governance fragmentation, historical wealth and technological expertise in Pittsburgh are highly concentrated in the region's largest philanthropies and in its most significant research universities. Beyond those entities, Pittsburgh experiences extreme concentrations of informal cultural authority among political and business elites. Pittsburgh has long struggled as a community to access and distribute material resources effectively and equitably. It has also struggled to ensure appropriate and consistent levels of community participation in conversations about resource development and use. Smart city systems in Pittsburgh have been closely linked to the interests, expertise, and good will of a relatively narrow band of experts in addition to policy and institutional design.

Both the Allegheny County Data Warehouse and the region's open data repository, the WPRDC, are strongly associated with specific individuals (Erin Dalton in the case of the Data Warehouse and Robert Gradeck in the case of the WPRDC) as well as with their commitments to good data practices in public administration. Like the design and operation of those organizations, collaborations between the City of Pittsburgh under Mayor Peduto and the Metro21 institute at CMU rely heavily on interpersonal relationships.

Those informal relationships mitigate the impacts of organizational polycentricity in part, because Pittsburgh's interpersonal professional culture has long been noted for its collegiality. Professional and personal networks tend to be small and dense. CMU is not only a source of research for Pittsburgh's smart city ventures. CMU's

degree programs are also the sources of graduates who have gone on to work on smart city practices in Pittsburgh, relying in part and building in part on a shared alumni identity. The University of Pittsburgh supplies not only a home for the WPRDC but also training and degrees and an informal alumni matrix for a number of Pittsburgh's smart city actors.

Nevertheless, smart city practice in Pittsburgh is composed almost entirely of elite leadership with strong ties to local business, to national and international technology companies, and to smart city experts elsewhere. That pattern echoes (though it does not precisely replicate) Pittsburgh's longstanding tradition of elite-led planning and strategy in both economic and cultural life. In a departure from that pattern, at times a reputation for smart city success in Pittsburgh has attracted expert talent from outside the region.

Informal relationships take on even greater importance as individual actors move from organization to organization and from role to role. They move both within Pittsburgh's smart city ecology and also outside of it, establishing links with national smart cities organizations. Movement expands the pool of shared interpersonal expert relationships and helps to cement bridges among different smart cities organizations. Movement also potentially dilutes that pool, creating a new social dilemma. Even without movement, this informal network constructs bridges for expertise to transfer from organization to organization and sector to sector. That bridging also connects Pittsburgh's smart city public sector and research communities to technology development practices in Pittsburgh's private sector, including startup and spinout companies and Pittsburgh extensions of global technology firms.

Power Asymmetries: Democratic and/or Community Participation

The role of the Pittsburgh community as a whole in defining and shaping technology-informed governance has been relatively small. Pittsburgh's smart city strategies have mostly been developed and deployed by the region's political, business, and research-based elites, with little provision for community governance. The relative absence of broader community engagement is unsurprising in historical terms. Since the end of Pittsburgh's steel industry, community distrust of newer technologies and their economic role has been a barrier to Pittsburgh's overall renewal (Sabel 1993). CMU has a legendary research program in computer science and robotics, but that success has never translated into broad community-friendly sensibility. With respect to technology-related policy, community-based interventions in recent years have been sporadic. The City of Pittsburgh adopted a Dark Sky Lighting ordinance in 2021 largely as a product of community-based research and activism. The city's Open Data Ordinance of 2014 likewise emerged in part from community interest. Both community efforts arose from engaged community volunteers rather than from broad, publicly supported outreach efforts.

Critical examination of the use of algorithms in public decision-making in Pittsburgh has come from the Pitt Cyber public policy program at the University of Pittsburgh (Pitt), likewise an initiative volunteered by expert community members rather than solicited by public authorities. That project is one of the few in Pittsburgh to recognize the significant misalignment between smart city program objectives and harmful community spillovers. In 2020, in response to an inquiry from Pitt Cyber, the City of Pittsburgh confirmed that it had discontinued a pilot predictive policing program, developed in partnership with CMU, called the "Crime Hot Spot Project." Pittsburgh's City Council followed that action with legislation banning police use of facial recognition technology without Council approval, although the Pittsburgh Bureau of Police later acknowledged using facial recognition technology (Clearview AI) during Black Lives Matters demonstrations in 2021.

The relatively small number of community-based interventions of that sort suggest that data collection and distribution practices may perpetuate rather than remedy inequitable living conditions in Pittsburgh with respect to health, wealth, and security both for individuals and for the community as a whole. Allegheny County's Allegheny Family Screening Tool (AFST), a data-based system for allocating family support services, has been criticized on that basis, though more of the criticism has come from outside of the Pittsburgh region than from inside it (Eubanks 2019). Smart city practices in Pittsburgh tend to consolidate rather than democratize control of Pittsburgh's governance in the hands of political and business elites.

Even within Pittsburgh's elite tier, the evolving strength of different voices is often difficult to discern. Elite leadership has gathered regularly in Pittsburgh to discuss strategies for economic development, though not specific to tackle smart technology issues. Decision-making, however, appears to be informal, consensus-based, and reliant on personal trust.

Given gaps between Pittsburgh's smart city leadership and community participation, smart city technologies might be deployed to enhance community governance capabilities. Pittsburgh's Burgh's Eye View data dashboard project and other, similar data dashboards are nods in that direction. It is not certain that smart city designers are yet providing mechanisms for genuine community participation about smart technology governance in fair ways.

Instead, concerns about smart city technologies have been raised in the context of broader economic development decision-making rather than in the form of broad, direct objections to potentially harmful smart city practices. Incumbent Pittsburghers in some neighborhoods affected by technology-based economic development have protested the disruption of long-settled living patterns. In one well-known instance, the City of Pittsburgh backed the development of a technology-themed facility on a site adjacent to the Monongahela River that once housed a major steel mill, now called Hazelwood Green. Among the site's amenities is a

closed track for testing autonomous vehicles. Residents of the adjacent neighborhood, which lies between the Hazelwood neighborhood and the campuses of Pitt and CMU, strongly objected to the construction of a transit link that would connect the riverside site and the universities, the so-called Hazelwood Connector. They cited both the disruption of their neighborhood and the fact that the transit link would benefit only the technology elites. The dispute continues, sharpened by the fact that in late 2021, the University of Pittsburgh and the Richard King Mellon Foundation announced that the foundation was committing $100 million to help the university develop a biotechnology manufacturing facility at the site, provisionally named "BioForge."

Information Asymmetries

Information asymmetries of various sorts mean that both acquiring too little data about Pittsburgh residents and too much data create opportunities for exploitation, corruption, and worse. I detected no evidence of bad faith or self-interested behavior in Pittsburgh's smart city practices but abundant evidence of how Pittsburgh's investments in partnerships with private high-technology companies and reliance on university-based research has skewed smart technology deployment so far. Residents may be unaware of political or historical conditions enabling data collection in certain domains and not enabling data collection in other domains. They may be led to believe that data collection and use is beneficial when in fact its impact is either neutral or possibly negative. Potentially harmful smart technology deployments may be difficult to detect and evaluate because robust mechanisms for transparency and oversight are not in place. That lack of salience or visibility not only limits residents' ability to engage meaningfully in community-based or democratic oversight. It also limits their awareness of the extent to which smart city systems affect fellow residents and community members.

Information asymmetries may also reflect and generate dilemmas as to producing and sustaining social trust. As residents of a city anchored in neighborhoods and small communities of long standing, Pittsburghers traditionally exhibit high degrees of social trust in one another. That tradition does not always extend to trust in leadership. For historical reasons, some community members may be insufficiently trusting of relevant public and private leaders to engage in community-based governance of technology systems. Other community members may be *too* trusting of leadership and therefore may be uninterested in participating in collaborative governance efforts. Trust-based dilemmas of these sorts relate not only to trust in Pittsburgh's leadership but also to trust (or lack thereof) among many Pittsburghers in technology itself, based on the region's mixed history in building an economy on foundations anchored in twentieth-century industrial technology.

Managing Community Identity

A final social dilemma concerns the construction of community identity, both related to smart city technology use and in general. Community identity refers to how Pittsburgh and Pittsburghers see and represent themselves with respect to their history and their ambitions. The challenge is that not everyone in Pittsburgh participates in those conversations, let alone in the same way or on the same terms. Shared history and shared ambition are distributed unequally, as they almost always are in a given city. Yet there are important points of commonality. Building on that commonality is part and parcel of Pittsburgh's smart technology practice. The City of Pittsburgh has tried to shape conversations about Pittsburghers' community identity in the innovation economy, by trying to communicate to the broader public the effective and equitable public administration that can accompany public technology use. Beyond computing, smart city practices are linked to Pittsburgh's efforts to reconstitute its public identity as an equitable and forward-looking "green" community in contrast to its older smoky self. Key actors blend advocacy and practice directed internally, to the Pittsburgh community itself, and persuasion directed externally, to political and economic development audiences outside of Pittsburgh. It is part of Pittsburgh's smart city practice that Pittsburgh should see itself in smart, technology-based terms. It is also part of Pittsburgh's smart city practice that others see Pittsburgh in those terms.

Shared city identity recapitulates additional social dilemmas. Both for historical and contemporary reasons, not all Pittsburghers experience or want to experience a shared "Pittsburgh" identity, whether related to technology use or otherwise. Promoting a collective, shared understanding of community identity may put at risk valuable ideas and behaviors as to spontaneity, serendipity, and personal development in both the experiences of residents and the behaviors of city planners, administrators, and public employees of all sorts. In contrast to cities such as New York and San Francisco that have long been celebrated for not only accepting but actively encouraging novelty and distinctiveness in human experience, Pittsburgh's reputation lies at the opposite end of that spectrum. Generalizing, Pittsburgh is a place that encourages and sometimes even celebrates conformity and social stability (Madison 2012). There are difficult but important balances to be struck between standardized, scripted, and even brittle behaviors in all elements of complex social systems, on the one hand, and improvised, innovative, and responsive behaviors on the other. Proponents of Pittsburgh's prospective, novel postindustrial identity, including those who develop and deploy smart technologies, have to observe a poorly defined boundary between promoting shared community identity and pushing Pittsburgh residents in the direction of community rigidity and even inflexibility.

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The summary of social dilemmas leaves important questions for further exploration and research. In what respects do the social dilemmas listed incorporate or point to subsidiary or overlapping social dilemmas? How should these dilemmas be characterized in terms of the tools, techniques, and concepts that are best used in elaborating their nuances and coming up with remedies? Are these urban planning challenges? Technology design challenges? Public administration challenges? Challenges regarding ideology, values, and purposes? All of these? How should observers and practitioners blend responses to questions of individual presence, identity, and activity with questions of collective, communal well-being? Documenting social dilemmas is only a beginning.

The next stage of this GKC-based investigation is describing the resources that have been implicated in smart technology systems in Pittsburgh; the actors involved in deploying, using, and overseeing those systems; and the roles that those people and organizations have played.

RESOURCES, ACTORS, ROLES, AND RULES IN PITTSBURGH'S SMART CITY SETTING

The character of Pittsburgh's smart city social dilemmas depends on the resource(s) at stake and the people involved. This section describes key knowledge, information, and data resources in Pittsburgh as a smart city, in context, adding to conventional or traditional inventories of urban resources in physical, social, economic, and political systems. These knowledge resources are examined in themselves and also as they are intertwined with other systems that characterize Pittsburgh. The section prioritizes description of who is involved in information governance, and what resources they draw on or manage. Of lesser interest are positives and negatives of technology and related phenomena as such (including "innovation" or "concentrations of power"), or abstract values as objectives (including "equity," "justice," and "democratic participation").

Data

"Data about Pittsburgh" consists of the first salient shared knowledge resource. Data includes data about Pittsburgh residents (including data about their interests, needs, and behaviors) and data about Pittsburgh as a physical place and space (including data about attributes of material infrastructures such as roads, lights, buildings, and parks). Future research may dig deeper into sector-specific and practice-specific data resources within this broad data domain. In a general sense and at both large and small scales, data about Pittsburgh capture the fact that quality of living in a communal context is a shared resource in a broad, fundamental sense.

Data that documents individual experience materializes that shared, aggregated resource and subjects it to new sorts of governance. The following sections describe

extensive efforts by the City of Pittsburgh, Allegheny County, and other, related actors to collect, store, share, and use data across a broad range of smart city systems. As a shared resource, urban data is new in part, because of the novel technologies used to collect and manage it. Pittsburgh's long history of collecting information about itself is documented in detail in the next section.

The various types of shared data in Pittsburgh include data derived from monitoring and observing environmental conditions (air and water quality; glare from street lighting; road damage) and human behavior (school attendance, movement of cars and buses). Conditions of data storage and use vary. Some are data stored in publicly managed systems for use by government actors (in particular, the Allegheny County Data Warehouse) and data stored in privately managed systems for use by both public and private actors (in particular, the WPRDC). Uses of the data vary widely as well. A lot of smart city data feeds into decision-making by government actors. Smart city data is formatted so that it is accessible and usable both by government actors and by residents and third parties, in particular, via the City of Pittsburgh's Burgh's Eye View data dashboards.

Expertise

A second shared knowledge resource is smart city expertise and expert governance itself, defined both by the positions and roles of decision-makers in relevant public, private, nonprofit, and higher education sectors and also by the substantive training, knowledge, and relational capital that individuals bring to bear on smart city practices. Both governance roles and the human beings who occupy them are subject to historical and political contingencies of numerous sorts. Shared expertise in Pittsburgh's smart city context resembles shared expertise in many government and governance contexts, with the proviso that Pittsburgh's industrial history has left a legacy of heavy reliance on locally developed and locally trained expert talent. Expertise in some cities is regularly and deeply refreshed by talented individuals moving in and out of the community, strengthening the social capital that underlies many effective city-specific and regional policy collaborations (Menashi 1997; Squazzoni 2009). For historical reasons, that has been much less common in Pittsburgh.

Even in Pittsburgh's comparatively static setting, unlike data and datasets (which in principle can be documented as shared resources via organizational and technical criteria), expertise is a shared knowledge resource that defies simple description. Experts and expertise may be recognized by virtue of role, by credentials, by formal peer recognition, and/or by social acceptance in some relevant community (Hartelius 2020). Expert networks are often fluid groups, and the expertise that they share is likewise dynamic. What counts as smart city expertise changes, as technology evolves, and as administrative and other governance strategies evolve (Eyal 2013). In Pittsburgh, smart city leaders and practitioners observe and learn from experiences in other places.

Taking those caveats into account, I observed a Pittsburgh-related "expertise community" for smart technology that includes substantial connections to CMU, both as a training ground for professionals in technology-based professions and as a key node in constructing research partnerships with industry related to smart city technology and practice; to Pitt, which has cultivated a node of similar type and function but which focuses less on industry partnerships and more on training professionals in public administration; to Pittsburgh's philanthropic and nonprofit sectors, much of which are staffed by graduates of CMU and Pitt; and to the City of Pittsburgh and Allegheny County itself. People and their associated expertise circulate regularly within this network, moving from CMU to Pitt (Robert Gradeck, the director of the WPRDC, worked previously at CMU); from the nonprofit sector to CMU (Rick Stafford, the founding director of the Metro21: Smart Cities Institute at CMU, was previously the Executive Director of the nonprofit Allegheny Conference on Community Development); from Pitt to the City of Pittsburgh (Chris Belasco, Enterprise Project Manager at the city's Department of Innovation and Performance, received his PhD from Pitt and serves as an adjunct professor there); and from the City of Pittsburgh to Allegheny County. Erin Dalton, Director of the Allegheny County Department of Human Services (DHS) and overseer of that department's AFST system, holds a master's degree from CMU.

These are tips of the proverbial iceberg. The number of personal and professional relationships evident in the construction of Pittsburgh's smart city community is too numerous to document in full detail here.

Community Identity

A final, central shared knowledge resource in Pittsburgh's smart city context consists of how individuals and small groups coalesce in time and over time to establish their collective identity as a city, producing both affective benefits and social trust that can underlie community development and improvement efforts (Sabel 1993). In short, Pittsburgh as an ideational construct is a critical shared resource, subject to social dilemmas as described earlier, that contributes to and follows from Pittsburgh's smart city trajectory. A number of intersecting processes generate that construct. Political mechanisms exist for building and sustaining it, along with the dynamics of spatial relationships. Because the process isn't coercive, some added ingredients are necessary. In significant respects cities are the durable products of processes of shared social cognition relative to everyday experience and relative to a place (Secor 2004). Individuals signal their affective experiences to others in both purposeful and casual ways; they tap into histories of urban identity and shape its direction going forward. Key actors and nodes in cultural networks reinforce the salience of certain behaviors and cultural signifiers. In Pittsburgh's technology practices, the largest local philanthropies have often performed this role, steering

investment in smart technologies in ways that align with inherited understandings of the best interests of the community.

Taking account of the fact that these processes themselves are mostly immaterial, variable, and highly imprecise, in many cities in the twentieth and twenty-first centuries, including Pittsburgh, social cohesion and trust built on urban identity has been purchased by corporate interests. Business and political elites in Pittsburgh have repeatedly tried to capitalize on local research and development activity in the robotics sector by publicly promoting the idea that Pittsburgh has become "Roboburgh" (Dieterich-Ward 2016).

Even more important, on a broad scale, have been corporate efforts associated with professional sports teams – American football, baseball, basketball, and ice hockey in the United States; ice hockey in Canada; football (soccer) in much of the rest of the world. In Pittsburgh, the shared community identity manufactured by workplace-based communities during the steel era (Slavishak 2008) has long since been transformed into community affection for its professional sports teams, particularly the Pittsburgh Steelers American football team. Fanaticism in support of the Steelers is arguably the only phenomenon that unites most Pittsburgh residents as "Pittsburghers" across the region. Fan identity is materialized typically via the "Terrible Towel," a small yellow terrycloth towel printed with a black "Terrible Towel" logo, that Pittsburgh residents and supporters of Pittsburgh professional sports teams twirl overhead while attending games in person, to celebrate and encourage Pittsburgh teams and fellow supporters. The Terrible Towel is an emblem and signal of Pittsburgh's shared identity. Black and gold are the official colors of the City of Pittsburgh and the dominant colors of each of the city's professional sports teams. They were part of the coat of arms of William Pitt, first Earl of Chatham, English Prime Minister in the late 1700s, for whom the city is named. Today, they form an integral part of Pittsburgh's symbolic identity, together with the region's steel history.

Actors and Roles in Action Arenas

Having sketched relevant shared resources and related social dilemmas, the next step suggested by the GKC framework is identifying how resources, actors, and their roles are assembled into "action arenas" or social contexts in which governance activity related to smart city technology takes place, generating outcomes. Taking account of public sector, philanthropic, and higher education institutions as key actors, smart city action arenas in Pittsburgh can be visualized in a general way as depicted in Figure 6.1.

Consistent with the discussion earlier in this section, the image represents Pittsburgh as a whole as an action arena. It shows both a series of subsidiary action arenas in the form of public sector entities, university entities, and philanthropic entities. It also identifies a distinct action arena that consists of actors anchored

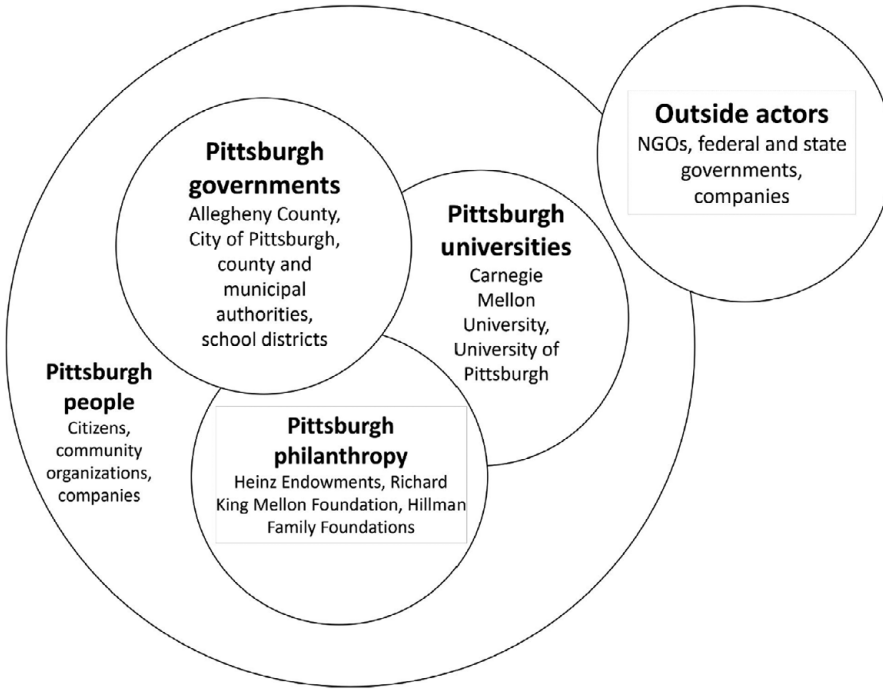

FIGURE 6.1. Smart city action arenas in Pittsburgh, Pennsylvania

outside of Pittsburgh that engage in some respect with Pittsburgh smart city practices, including technology vendors, nonprofit organizations, and federal and state governments. The residents of Pittsburgh, both in themselves and in the form of community organizations and private sector companies, appear as constituent members of the macro Pittsburgh action arena. For-profit firms are not represented as an action arena in themselves, because I could not discern any evidence of collective or communal firm-based governance behavior in Pittsburgh, or with respect to Pittsburgh. Instead, both local private firms and national and international private firms interacted regularly with key actors in the primary government, university, and philanthropic sectors, selling technology and sometimes offering relevant expertise.

Two important considerations dictate relying only generally on the characterization represented in Figure 6.1, rather than too narrowly or precisely, in exploring smart city governance in Pittsburgh. First, each of the action arenas identified in Figure 6.1 signifies a number of smaller action arenas nested inside it. Each action arena, large and small, is subject to a greater or lesser degree to the resource descriptions and social dilemma characterizations supplied earlier. The overlapping circles speak to data itself as a resource and to governance expertise as a resource.

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For example, Pittsburgh governments include the City of Pittsburgh and, within the City of Pittsburgh, several distinct administrative departments. Pittsburgh universities include CMU and Pitt. CMU includes various research and other programs within CMU, such as Metro21, the CREATE Lab, and individual faculty members' research programs. Likewise, Pitt includes various subsidiary units and researchers. Each of those should be considered an action arena with respect to smart city initiatives. Moving flexibly from larger to smaller scales in that regard is consistent with the intuition that smaller action arenas may be nested within larger ones.

Second, Figure 6.1 signifies that action arenas in the smart city setting are evidence of a polycentric social, cultural, and political system. Polycentricity highlights substantial overlaps in formal jurisdictional authority and in informal governance responsibilities. Yet that focus may detract from the fact that both formal and informal boundaries among action arenas often are less significant in Pittsburgh than interpersonal relationships among individual actors, including both social and political relationships. Smart city initiatives in Pittsburgh often require not only substantial collaboration among and across several polycentric centers but also among and across particular individuals, whose histories and forms of expertise accompany them as they migrate from organization to organization even within the Pittsburgh city action arena as a whole. In short, the important attention given to action arenas generally tends in Pittsburgh's specific case to give insufficient weight to individual agency and to idiosyncrasies of personal history and attitude. As between governance system and structure, on the one hand, and personality on the other, a great deal of Pittsburgh's smart city experience has been rooted in the latter.

Within these action arenas, judgments about how governance is produced are fluid. Smart city governance in Pittsburgh has not been heavily formalized by public actors. Formal, public law governing smart city activity in Pittsburgh is relatively modest in scope. A City of Pittsburgh ordinance passed in 2014 defines municipal obligations relative to publishing public-generated datasets in a publicly-accessible repository. Today, that repository is the privately supported and operated Western Pennsylvania Regional Data Center (WPRDC). Although the legal obligations and the creation of the WPRDC were part of a coordinated governance strategy for sharing data collected by the City of Pittsburgh and Allegheny County (with the operating costs of the WPRDC largely underwritten by leading local philanthropies), the repository was funded and launched only after the city subjected itself to a duty to share information, and as of late 2021 the city was not yet fully compliant with the law. Other City of Pittsburgh ordinances mandate certain private sector compliance and disclosure in connection with green construction and aspire to return "dark skies" to Pittsburgh via procurement and installation of improved streetlighting.

Informal rules, by contrast, govern most of this activity. The highest profile individual actors in Pittsburgh's smart city ecology emphasize that in developing

and deploying smart technology, they prioritize the interests of residents, both in term of how data is collected and used and in terms of acting consistently with principles of good government. There is no doubt that those views are genuine and motivated by good faith considerations. There is no doubt that views of what is possible and what is best are informed partly by deliberation about the future of Pittsburgh and about the future of good government generally, facilitated by conversations with colleagues in other places. There is also no doubt that these views are informed by knowledge about peer community practices and the uses of technology supplied by industry consultants and other third parties.

In practice, key Pittsburgh smart city actors invoke and rely on industry-standard practices regarding data security and data privacy. The City of Pittsburgh migrated its data storage architecture to Google Cloud starting in 2021, and the contract governing that commercial relationship emphasizes Google's security practices. That contract does not specify undertakings by any party as to the privacy of residents or other data subjects. Interviews and document reviews for this study revealed no standard or typical practice by the City of Pittsburgh relative to sharing information with residents about possible privacy interests implicated by deploying smart city systems, other than consultations as needed with lawyers employed by the city and with third-party technical and policy experts. Nevertheless, the purpose of the move to Google Cloud is unambiguous: to use the Google Cloud infrastructure to build a "data lake" of pooled data for use in data analytics and data reporting. In homage to the specifics of Pittsburgh's geography, and in contrast to Allegheny County's Data Warehouse, the City of Pittsburgh pool is known as "Data Rivers."

By contrast, public access to the WPRDC repository is governed, formally, by a click-through "Data Use Agreement." That text is directed almost entirely to exonerating WPRDC and its sponsors and supporters from possible liability associated with using WPRDC-hosted data. As a practical matter, the WPRDC has no resources to follow up on or monitor compliance by community-based data users, and the disclaimer, like many click-through disclosures online, is both legally enforceable and, practically speaking, likely to be ignored. The presence of the disclosure does signify at least modest acknowledgment by WPRDC and its partners and sponsors that confidentiality, privacy, and security concerns are present when public data about resident activity is collected, curated, and shared. The WPRDC's judgments about those values operate at a level that is tailored to its perception of its interests and those of city residents – as well as to the level of the University of Pittsburgh, which is WPRDC's parent organization. Other actors express different judgments. Some datasets produced by the Allegheny County Department of Human Services have not been accepted for deposit with the WPRDC on account of differing understandings as to privacy protections afforded the subjects in the Allegheny County data.

The last notable feature of smart city governance in Pittsburgh, framed by the action arenas identified in Figure 6.1, is that smart city actors perceive that they are

participants in a gift economy. That characterization applies both to their dealings with one another and also, at times, to their dealings with members of the broader Pittsburgh community. This is characterized partly in "pay it forward" terms, with the expectation that a kind of informal karmic justice associated with free and open sharing of civic data would eventually return benefits to the donor. It is characterized partly and more concretely in terms of overcoming obstacles to technology deployment by giving away time and expertise for free, particularly within large government organizations where time and technology expertise are not widely distributed in staff or budget terms. Representatives of technology firms that sell smart city technologies to cities distinguished their strategic consulting counsel as to smart technology uses from separate sales efforts. That perspective has both gift-oriented and profit-oriented motivations. The gift-oriented practices and attitudes confirm the existence of an informal network of favor exchange and loosely patterned cooperative behavior rather than a system of strong reciprocity or altruism (Jackson, Rodriguez-Barraquer, and Tan 2012). The content of governance practices in Pittsburgh's smart city contexts, or what might be termed Pittsburgh's smart city "rules-in-use," appears to be less significant for what they require or permit and more significant in that they confirm the existence of a community of smart city practice and expertise.

CONTINGENCY AND CONTEXT: PITTSBURGH'S SMART CITY HISTORY

Smart cities emerge and evolve in ways that aren't captured by descriptions of the political economy of cities (Frug 1999; Glaeser 2012), by the political economy of modern ICTs (Goodman and Powles 2019; Latham and Sassen 2005), or even, as per the previous section, by the logic of thinking through relationships among resources, dilemmas, actors, and rules. Pittsburgh's smart city experience and smart city governance cannot be understood or interpreted effectively without giving significant attention to Pittsburgh's history. The GKC framework enables researchers to include historical context in their exploration of commons governance.

For more than a century, Pittsburgh has been in the forefront of urban planners' efforts to acquire data about urban conditions. That's a description, not a celebration. Pittsburgh's efforts to be systematic, productive, and not harmful in using data about itself have been inconsistent and intermittent. Sometimes, Pittsburgh has put that data to productive use. Sometimes, Pittsburgh leaders have ignored the data. This section shows how, and in the process it sets the stage for explaining many of the wider directions and smaller choices evident in Pittsburgh's contemporary smart city governance. Many of its modern smart city moves are comprehensible only in the specific context of the detailed history of Pittsburgh as a distinct place, geographically, economically, politically, and sociologically (Lubove 1969; Madison 2012), and as the place that Pittsburgh and Pittsburghers imagine that Pittsburgh was, is, or may become (Neumann 2016).

The Origins of Pittsburgh's Intelligence

When it comes to smart city governance and to knowledge-sharing practices in particular, Pittsburgh is significant as much for who and what is left out as for who and what is included. Those patterns of inclusion and exclusion have deep roots.

During the 2013 campaign that led to his election as the sixtieth Mayor of Pittsburgh, Bill Peduto published a list of 100 actions his administration would initiate during its first 100 days. Number one on the list was "A 21st Century Pittsburgh Survey." A Pittsburgh native and long-time member of the Pittsburgh City Council, Peduto brought with him a deep knowledge of the city's history and a wish to see it achieve a twenty-first-century version of its twentieth-century glory. As mayor, Peduto aimed to replicate one of the first and greatest works of urban sociology ever produced for an American city.

The original *Pittsburgh Survey*, funded by the Russell Sage Foundation in New York and Chicago (then the Russell Sage Foundation for the Improvement of Living Conditions) and published between 1908 and 1914, appeared initially in thirty-five magazine articles and eventually was collected in six volumes of research (Greenwald and Anderson 1996). In its time, it was a first-of-its-kind, uniquely comprehensive data-focused examination of social welfare in an American community, synthesizing research on living conditions, working conditions, and industrial production in a single place (Lubove 1969).

Taking account of both the city itself and what the Survey, following common practice at the time, called the Pittsburgh Steel District, Pittsburgh was an enormously and almost incomprehensibly productive industrial place. During the nineteenth century it was known as the "Iron City." During the twentieth century, the nickname was updated to the "Steel City." The metallurgical metaphors were paired with a third, the "Smoky City," due to Pittsburgh's dirty air. An 1860s Pittsburgh travel writer noted that Pittsburgh was so vibrant with the fires and smoke of industry that he called Pittsburgh "hell with the lid taken off," and he meant that as a compliment (Madison 2012).

The "Steel District" geographic designation mattered to both researchers and local leaders more than a formal "City of Pittsburgh" identity, and related geography matters even today. Much of the steel production and associated industrial activity in Pittsburgh, including company towns, was located outside the City of Pittsburgh proper. Pittsburgh's coal mines and steel mills were almost always located up Pittsburgh's valleys, particularly up the Monongahela River and down the Ohio River, rather than in or near the urban center. The mills took advantage of the transportation economies that the rivers afforded relative to importing iron ore and exporting finished product.

Given the scale of the industry, workers associated with the steel industry – largely immigrants, in the late 1800s and early 1900s – were distributed around the Pittsburgh region. They were concentrated partly in company-supplied housing

and partly in communities and neighborhoods adjacent to related industrial complexes, distributed across both the city and also in the less accessible, riverside locations that housed the largest mills. For most of its residents, the Pittsburgh Steel District was an awful place to live, with much of the population living in structures built to nonexistent housing codes and with virtually no modern water or sewer service.

Researchers for the Pittsburgh Survey aimed to document all of that, not to highlight anything specific to Pittsburgh but to use Pittsburgh as an exemplar of industrial conditions and social welfare across the United States. This was not, primarily, aimed at local reforms. The Survey was developed, researched, and written in response to an intervention by a small group of Pittsburgh business and community leaders who were aligned with the Progressive political movement nationwide. The vehicle for their interest was the Charities Publication Committee of New York; the host publication was *Charities and the Commons: A Journal of Constructive Philanthropy*. The point was fundamentally about Progressive politics: using data to support anti-corruption reform of public administration (out with patronage systems, in with the experts) and both voluntary and government intervention to improve residents' social welfare.

(Pittsburgh wasn't immune to ordinary efforts to improve urban living conditions. Around the same time that the Survey was researched and written, the City of Pittsburgh commissioned a report on its transportation infrastructure from a Chicago-based engineer. The report, released in 1910, was titled *Report on the Pittsburgh Transportation Problem* and criticized the lack of integration of the region's many local streetcar companies.)

The Pittsburgh Survey generated massive amounts of data about industrial life, living conditions, and the environment. Locally, in practice, its impact was limited. (Pittsburgh had more success consolidating its streetcar operations.) To the extent that Pittsburgh absorbed the Survey's lessons and welcomed political Progressivism, the movement took on a distinctly business-friendly character. The historian Roy Lubove chronicled in detail how the charitable impulses of the Pittsburgh business community married its market-dominating impulses during the 1920s, 1930s, and 1940s. Improvements were directed to physical infrastructure rather than to measurable changes to underlying questions of equity and social justice. Pittsburgh business leaders in partnership with Pittsburgh politicians endorsed and advanced housing reform legislation, investments in urban planning, and modest progress toward modern infrastructure, all in the interest of protecting and advancing Pittsburgh's market positions in industrial production (Lubove 1969).

Throughout, the initiative to rely on the data and to begin the reforms depended on the essential political power of Pittsburgh's business elite. That group consisted of a relatively small number of senior men serving as chief executives of large industrial firms that were, for all practical purposes, family-run enterprises. In the late 1800s and early 1900s, the group was led, politically, culturally, and economically, by

Andrew Carnegie and Henry Clay Frick, industrialists, and Andrew Mellon, financier. Through the 1930s, their heirs and successors carried on the tradition of Pittsburgh leadership by Pittsburgh industry.

In 1943, informal collaborations between Pittsburgh's business leaders and government leaders were consolidated and formalized in the Allegheny Conference on Community Development (ACCD), an early and durable public–private partnership in the form of a nonprofit corporation. The ACCD was energized largely by the leadership of the Mellon family banking and oil, gas, and coal concerns (embodied initially in Richard King Mellon), together with chief executives of other leading Pittsburgh companies (men named Mellon, Heinz, Kaufman, Hunt, and Hillman, and companies including Gulf Oil, Alcoa, U.S. Steel, Pittsburgh Plate Glass (now PPG Industries), and Heinz). This was *noblesse oblige* on the part of the individuals involved as much as corporate direction of state activity, in the guise of philanthropy. (The original by-laws of the ACCD required that member entities participate in the person of the company's CEO or president, making elite governance formal and explicit.) The ACCD was made effective and durable by the active participation of Mayor David Lawrence (later Governor of Pennsylvania) and the local Democratic Party machine. The by-laws were later amended.

In the hands of the ACCD, in most respects, what needed to be done in Pittsburgh meant civic improvements to produce and reproduce the economic successes that defined the first half of Pittsburgh's twentieth century. The ACCD took on the roles of coordinating regional planning across both business and local governments in the Pittsburgh region and of building community consensus around specific initiatives. In effect, the City of Pittsburgh and surrounding communities outsourced much of the visioning process to a public-spirited top tier of the private sector.

During the 1950s, the payoffs mostly consisted of productive investments in infrastructure: cleaning Pittsburgh's smoky air by banning coal-fired home furnaces; cleaning the worst elements of Pittsburgh's dirty rivers by regulating waste disposal; building modern highways and air transportation through Pittsburgh; organizing formal public health institutions; and redeveloping the most industrial sections of Pittsburgh's Central Business District, replacing train sheds and related facilities with modern skyscrapers and parks. That initial round of improvements is often characterized by both historians and boosters as the "Pittsburgh Renaissance" (Madison 2012).

During the 1960s, the payoffs mostly meant urban renewal, clearing out so-called slums (predominantly Black neighborhoods) and replacing them with amenities for Pittsburgh's (predominantly white) professional class. The steel-domed Civic Auditorium, opened as a concert venue in 1961 (and demolished fifty years later, having acquired an afterlife as a sports arena), was intended to showcase Pittsburgh's metals industry for the benefit of prospective investors in the region. Its construction eradicated the much of the cultural center of Black life in Pittsburgh, known as the

lower Hill neighborhood, home to a thriving arts community and to more than 8,000 people.

Pittsburgh's Intelligences of the Late Twentieth and Twenty-First Century

That rhythm – a data-fueled baseline for good government and welfare improvements, followed by an elite-driven, intuition-based, largely privatized set of visions, strategies, and tactics – defined Pittsburgh for much of the twentieth century. The pattern can be documented and illustrated further with efforts by Pittsburgh public authorities – and iconoclasts.

Around the same time that the Pittsburgh Survey was being produced and published, Frederick Law Olmsted, famous as one of the designers of New York's Central Park and other well-known public parks and recreation facilities in the United States, was retained by Pittsburgh's business elite to produce plans for Pittsburgh. As planners and designers, Olmsted and his firm would rely on the bureaucracy of urban planning to implement their visions, but their charge was to tame Pittsburgh's appalling physical and social conditions and, in cleaning and regularizing the conditions of urban life, to instill the working people of the city with "appropriate" moral order (Ingham 1991). This was Progressivism at work in a different register, top-down rather than, as with the Pittsburgh Survey, data-driven and bottom-up. As in the work of Ebenezer Howard (author of the utopian planning guide *Garden Cities of To-morrow: A Peaceful Path to Real Reform* in 1898), orderly and systematic urban planning – in a manner of speaking, the smart city of yesteryear – was a mode of social reform (Beevers 1988).

Olmsted's vision, delivered in a report in 1910, was adopted only in part. As with the results of the Survey, pragmatic physical improvements were pursued while social justice implications were ignored. Today, many of Pittsburgh's larger boulevards and bridges owe their origin to Olmstead (Bauman and Muller 2006). Pittsburgh's regional parks and nearby vacation destinations were built in the same era, displacing local working class communities in the interest of the patronizing impulses of the business community (Dieterich-Ward 2016).

The top-down planning impulses of Pittsburgh's power structure had additional manifestations, with a more entrepreneurial character. Pittsburgh's most celebrated work of modern architecture, the Frank Lloyd Wright masterpiece Fallingwater (a vacation house located in the Allegheny Mountains just southeast of the city), was commissioned by Edgar Kaufmann, Sr., a local department store magnate. Kaufmann was so taken with Wright that he commissioned the architect in the 1940s to produce a series of futuristic plans for a civic center and related infrastructure to be built at the Point, the tip of the Downtown Central Business District. The civic center never came to pass; there is little evidence that the plans were ever seriously considered by the city. Kaufmann's instincts were on the right path, however. The Point was leveled and remade as part of the Pittsburgh Renaissance

during the 1950s. Among the new, related developments was a series of high-rise cruciform buildings clad in chrome-alloyed steel that evoke the 1920s Radiant City "Towers in the Park" vision of modernist, technocratic urban planning promoted by the architect Le Corbusier.

The planning impulse did not abate. In 1963, researchers at the University of Pittsburgh, together with the Pittsburgh Regional Planning Association (a subsidiary of the ACCD), produced a three-volume study addressing the economic prospects for the region, titled *Economic Study of the Pittsburgh Region* (Chinitz 1961; Lubove 1965). It concluded that Pittsburgh's economy was stagnating as the era of structural steel production in the area was likely coming to an end. The study called for a transition to a more technology-driven economy. That recommendation was all but ignored. A complementary effort to develop a comprehensive computer simulation of Pittsburgh's land-based resources to support data-driven planning efforts was terminated and abandoned before it could be completed (Brewer 1973).

At the other end of the spectrum of community institutions, federal antipoverty programs and model cities initiatives during the 1960s encouraged the development of neighborhood-specific organizing in Pittsburgh. Those organizing efforts included the preparation of a Pittsburgh Neighborhood Atlas during the early 1970s, which surveyed residents about neighborhood satisfaction and satisfaction with public services, and documented data from seventy-eight Pittsburgh neighborhoods about real estate prices, loans and tax delinquencies, and welfare assistance. Funded largely by the University of Pittsburgh through its School of Social Work and completed in 1977, the Atlas and the organizing behind it contributed significantly to defining Pittsburgh's neighborhoods in their modern configuration (now ninety in all) and to cultivating the neighborhood – otherwise omitted from the vision advanced by the Allegheny Conference – as an effective locus for community participation in planning, reconstruction, and economic development (Cunningham et al. 1976; Lubove 1996).

The Atlas was conceived and produced specifically as a counterpoint project, contrasting common perspectives against elite perspectives, rather than as a complement to the efforts of regional leaders. Following the collapse of the steel industry in Pittsburgh in the early 1980s, Pittsburgh leaders again promoted efforts to anchor the region in integrated visions of technology-based industry. In 1985, a coalition of Pittsburgh leaders (the ACCD, the presidents of the University of Pittsburgh and Carnegie Mellon University (CMU), the Mayor of the City of Pittsburgh, and the political leaders of Allegheny County) published the Strategy 21 report, proposing an economic development plan for the region in the wake of the end of the steel era (Deitrick and Briem 2021). The report recommended pursuing an elaborate, data-focused effort to diversify the region's economy away from its historical reliance on heavy manufacturing. Only one of the report's significant recommendations was adopted. Pittsburgh built a major new international airport.

Out of the Furnace and Toward the Smart City

Pittsburgh's historical tension between empiricism and elitism offers the key byway into understanding Pittsburgh's smart city conditions today, even as the specific shape of that tension changed. It has been suggested that the rise of Pittsburgh's two leading research universities and its largest philanthropies during the latter half of the twentieth century, and the decline of Pittsburgh's old industrial and financial sector firms, brought with it a loss of interest in the cultural fabric of the city. The old industrialists' possibly patronizing but nonetheless real focus on the lives of the people disappeared in favor of a focus on metrics (Lubove 1996). The criticism is overstated. In practice, governance technologies and tactics changed, and with new tactics came new goals. Good governance became measurable, at least in principle, rather than simply evident in residents' and companies' experience. The new players emerging in the later twentieth century and early twenty-first century brought forward a new and explicit focus on public administration and governance as goals in themselves, sharpening a distinction between this more modern, technocratic attitude and the *noblesse oblige* that inspired the original ACCD.

In other words, the era of a small number of supremely wealthy families in Pittsburgh actively driving the direction of the city, as heirs to the industrial and financial leaders of the late nineteenth century, ended. New key players emerged, taking their places alongside political leadership and the leaders of the region's largest private companies, particularly the leaders of the foremost universities in Pittsburgh; the leaders of its largest employer; and the leaders of its major philanthropic organizations.

In 2013 and early 2014, Mayor Peduto's list of 100 inaugural actions did not include turning Pittsburgh into a smart city or producing a smart city strategy. The list of 100 actions did include a number of items that fall within anyone's definition of smart city administration. More important than the list itself, however, the Peduto administration helped to consolidate preexisting Pittsburgh assets and investments in data-driven government and private sector technology development, and to accelerate Pittsburgh's reliance on smart city systems by weaving narratives that expressed smart city visions. This subsection summarizes the assets first, and then the visions.

Assets and Liabilities

Local politicians and promoters today tell a tale of Pittsburgh as a city that is capitalizing rapidly and thoroughly on the region's historic, contemporary, and distinctive strengths in computer science and robotics (TEConomy Partners, LLC 2021). Among US cities, perhaps only Cambridge, Philadelphia, and Palo Alto share Pittsburgh's justifiable claim to having birthed so much of both modern computer science and internetworking technology. Chief among Pittsburgh's historical and

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contemporary assets in that regard is an elite private technical university founded by Andrew Carnegie (CMU, formerly known as the Carnegie Institute of Technology, or Carnegie Tech). CMU is famed as the home of much of the world's earliest research on computing and today focuses a significant amount of its research on engineering, computing, and robotics. CMU anchors a small but growing technology economy directed largely to autonomous systems specifically and to ICTs generally. Pittsburgh aims to use those strengths both massively to improve the quality of Pittsburghers' lives and also to attract new industries and employers to the area. The smart city in Pittsburgh is inseparable from broader enthusiasms about technology and economics. A corresponding new political economy is in formation, produced by and in response to the expectations of Pittsburgh's newer, younger, more technologically oriented population (Winant 2021).

To Pittsburgh insiders, CMU's influence on Pittsburgh's "smart" trajectory has been important but not uniquely deep or durable. Certainly, CMU is one key institutional player locally. Its first notable smart city technology venture, the urban design research center at CMU's School of Architecture known as the Remaking Cities Institute (RCI), opened in 2006 with funding from one of Pittsburgh's leading foundations. The RCI led in 2009 to the formation of a traffic- and transportation-themed research center to bridge academic and industry interests, and in turn that organization, Traffic21, led to the formation in 2014 of Metro21: Smart Cities Institute, with a similar theme but with a smart cities focus. Metro21 coordinates or supports a variety of smart city research projects, including 3D visualizations; landslide warning systems; air quality and light pollution monitoring; paving and curb design; and programs for public art. Mayor Peduto later referred to Metro21 as the City of Pittsburgh's research and development wing with respect to smart city technology (High 2017). In the pluralistic CMU environment, the separate Robotics Institute, now the focal point for the university's long-standing research program in robotics, houses the CREATE Lab. CREATE stands for Community Robotics, Education and Technology Empowerment, and the lab differs from Metro21 in its focus on community engagement and transformation through community-generated technology innovation.

But like most research organizations of its type, CMU looks to achieve impact and status on a global stage rather than principally in its backyard. Its investments in Pittsburgh are typically part and parcel of using locally developed experience and data to expand its research impact much more broadly.

In the size and scale of its research enterprise, CMU is dwarfed by a second world-leading university, the University of Pittsburgh, or Pitt. Pitt's impact on the regional economy has been more substantial than CMU's, partly because Pitt is a publicly affiliated institution and in some respects prioritizes local and regional community impacts in its research and teaching programs, partly because Pitt enrolls far more students and employs far more faculty and staff, and partly because Pitt's primary research interests lie in the health sciences, not ICTs. The clinical care organization

spun off from Pitt's medical education complex, formerly called the University of Pittsburgh Medical Center and today called UPMC Health Systems, is the largest employer in the Pittsburgh region and a close partner of the University of Pittsburgh. Only recently have Pitt researchers shown any real interest in smart city technology, but as described further later, Pitt's history and identity give it a substantial, important, and necessary presence in Pittsburgh's smart technology investments.

The rise of Pittsburgh's two leading research universities is half the story of the shift in emphasis in Pittsburgh's leadership during the latter part of the twentieth century. The other half of the story is the emergence of large-scale philanthropies as critical leaders and shapers of all aspects of regional development. Pittsburgh's philanthropic sector is extraordinarily large in proportion to the size of the city, a phenomenon that is usually traced to the public generosity of the city's industrial leaders extending back to Andrew Carnegie (Buechel 2021). Three of them are particularly notable both for their contributions to Pittsburgh life as a whole and to their participation in ICT-driven economic development and, now, smart city systems.

One is the Heinz Endowments, with assets of over $1 billion, which is the combined form of the Howard Heinz Endowment and the Vira I. Heinz Endowment. Both Heinzes were members of the family associated with H. J. Heinz Company, today Kraft Heinz, originally headquartered in Pittsburgh. The second is the Hillman Family Foundations, a collection of eighteen separate foundations administered centrally in Pittsburgh, with just under $500 million in assets. Henry Hillman was a mid-century industrialist and investor in Pittsburgh. Third is the Richard King (R. K.) Mellon Foundation, with assets of approximately $3 billion. R. K. "Dick" Mellon was a member of the Mellon banking family.

These three foundations, among many philanthropic organizations in Pittsburgh, exercise their leadership and influence partly through their grantmaking. Pittsburgh has relatively little of the risk capital that characterizes twenty-first-century technology markets in Silicon Valley, New York, and Boston. Early funding characteristically comes from Pittsburgh's philanthropic sector for a broad range of activities: for public sector projects, technology infrastructures for private sector initiatives, for startup ventures in the nonprofit sector, for significant higher education initiatives, and for public–private collaborations. Influence is exercised in less direct and more informal ways, as foundation leaders work with project sponsors to shape initiatives and broker relationships among multiple possible participating entities. Foundation leadership in Pittsburgh has come to exercise much of the leadership responsibility, and receive much of the cultural deference, once associated with Pittsburgh's industrial CEOs. The foundations and their leadership are often perceived by other Pittsburgh elites as honest brokers.

Meanwhile, Pittsburgh's industrial heritage contributes to its smart city strategies and goals in several underappreciated ways, both for better and for worse.

Geography is the first. On the map, Pittsburgh sits on the western edge of a north–south mountain range that runs diagonally from New Hampshire in the north to

Georgia and Alabama in the south, changing names as it goes. In Western Pennsylvania, these are the Allegheny Mountains, and they give Pittsburgh both its extremely hilly character and the two rivers that converge at the tip of the broad peninsula on which Pittsburgh's Downtown neighborhood sits. (Pittsburgh's Downtown is sometimes known as the Central Business District, or CBD.) That convergence, known as "the Point," serves as the head of the Ohio River and the focal point for modern Pittsburgh's business and government institutions. Pittsburgh's geography is mostly a dilemma – not a social dilemma, but a physical obstacle. Pittsburgh's hills and valleys are significant barriers to population and material mobility of various sorts and thus the material foundations for its fragmented governments, its transit and transportation challenges, its community equity (and occasional lack thereof), and its uneven progress toward pollutant-free air and water. Geography is also opportunity. If smart technologies can be proved to be effective in Pittsburgh's difficult territory, then their success in less irregular urban settings is all but assured.

Imagined identity is the second. In the public imagination, particularly across the United States as a whole, twenty-first-century Pittsburgh may seem to be bigger and more substantial as a population and economic center than it actually is. Some of that public identity likely derives from the persistence of the public impression of twentieth-century Pittsburgh industry. Many Americans know Pittsburgh not as an actual producer of steel but as the place that once dominated the American steel industry. The mental image of industrial size and impact is carried forward via the city's professional sports teams. The exceptionally successful Pittsburgh Steelers American football franchise has a noted global following to go with its passionate regional fan base. Imaginary Pittsburgh often gives regional leadership the ambition to think in big terms, particularly with respect to ICTs in both private and public sectors, often out of proportion to Pittsburgh's likely economic trajectory. Pittsburgh's public and private leaders regularly put forward the idea that Pittsburgh's postindustrial destiny is inextricably linked to restoring Pittsburgh's leading role on the stage of sophisticated world cities.

Actual size is a third. The impression that Pittsburgh's historical scale continues to characterize Pittsburgh today is mistaken. Pittsburgh is modest by any standard. Today, Pittsburgh counts roughly 300,000 residents within the borders of the city itself. The metropolitan region of which Pittsburgh is a part, also often referred to (confusingly) as Pittsburgh, has roughly 2.3 million residents. The majority of those (roughly 1.2 million) live in Allegheny County, of which Pittsburgh is the largest city. The rest live in nine counties that surround it. These occupy Pennsylvania's southwestern corner. Philadelphia, much larger and the largest city in Pennsylvania, sits in the state's southeast corner, roughly 300 miles to the east. The small size of the City of Pittsburgh relative to the size of the county and the metropolitan area is due to historical patterns of development and economic dislocation. (The population of the City of Pittsburgh peaked between 1930 and 1955 at roughly 700,000; the

metropolitan population of that era was roughly 3 million people.) Modern Pittsburgh's size has contemporary benefits in the smart city context: the size of the professional class in Pittsburgh is quite small, both in its geographic dispersion and in its absolute size. Its expertise network has an intimacy that may be missing in larger cities.

Population dispersion, wealth, and mobility is a fourth. All cities have heterogeneous populations; Pittsburgh's heterogeneity simply has its own, highly context-specific variations. Industrial and postindustrial patterns of economic activity impact Pittsburgh demographics more than the reverse, and the strengths and weaknesses of both public and private sector ICT systems on the ground are related in part to the industrial geography (and now postindustrial geography) of Pittsburgh's neighborhoods and suburbs. On the ground, that means that the bulk of Pittsburgh's population settled across the region in close proximity to its largest industrial plants. Because those were fixed in place, throughout the twentieth century population churn was low relative to patterns in similarly sized and larger cities elsewhere, in terms of both internal mobility among communities and population migration into and out of Pittsburgh.

That pattern of immobility has proved difficult to shift following the collapse of the steel industry in the early 1980s. A handful of City of Pittsburgh neighborhoods and nearby suburbs now experience more population dynamism and higher incomes, in that they are dominated today by families and others working in the professions, in newer ICT-related industries, in healthcare, and in higher education. Elsewhere, the end of the steel era largely consolidated existing demographics, with communities either depopulating or replicating themselves at smaller scales. The towns where the early steelworker populations were largest, particularly up and down Pittsburgh's rivers, remain among the hardest hit economically by the end of the steel industry. Because Pittsburgh's demand for labor was essentially fixed by the steel mills shortly after the turn of the twentieth century, the American Great Migration of Black Americans did not impact Pittsburgh to the degree that it affected other industrial cities, including Chicago, Detroit, and Cleveland. The city's Black population, small and fragmented to begin with, has been migrating steadily out of the city since the turn of the twenty-first century, moving mostly toward Pittsburgh's eastern suburbs. The lack of economic expansion in Pittsburgh during the second half of the twentieth century, and the corresponding lack of migration to the city, means that its Hispanic and Asian and Asian American communities are minute in comparison to their presence in Pittsburgh's peer cities.

Transportation and transit are a fifth. Today, transit links between and among neighborhoods and towns around the region are notoriously weak, compounding mobility and access problems created by Pittsburgh's geography and reinforced by twentieth-century population dispersion. Regional roadways and urban railways were built in the early twentieth century to accommodate industrial needs and residential patterns that suited the mills. But the topography of the region and its

focus on infrastructure developed by and for industry left the region without a road system or transit system coordinated and ready for development at a larger scale. The Pittsburgh Railway Company consolidated streetcar lines across the region shortly after the turn of the twentieth century, but, like streetcar operators across the United States, beginning in the late 1950s it yielded to political, economic, and social imperatives to invest in highways. Yet modern interstates penetrated Pittsburgh only in part; as steelworkers started to move out of mill towns and into emerging post-World War II suburbs, the architecture of the early interstate highway system in Pittsburgh largely aligned with the development of those newer communities rather than with broader regional interests. Transit and transportation systems largely reinforced the region's geographical fragmentation.

Adding these industrial carryovers and contemporary interests together yields Pittsburgh's ongoing intense attachment to the small-scale hilltop and river valley communities and neighborhoods that developed in the shadow of the steel mills more than a century ago. The American political system is famously fragmented, but even against that baseline Allegheny County shines for its extraordinary acceptance of micro governments. It is home to 130 self-governing municipalities, including the City of Pittsburgh. That's the largest number of autonomous governments of any Pennsylvania county and both the cause and the effect of the region's fragmented political governance. Moreover, the City of Pittsburgh itself formally recognizes ninety distinct neighborhoods, many of which are home to semi-autonomous economic development organizations. Allegheny County has forty-three separate school districts, each of which possesses independent taxing authority under Pennsylvania law and, like the county and its municipalities, its own procurement system. For historical and now cultural reasons, these communities are customarily focused intensely on inward-facing community participation and governance rather than outward-facing questions of broader regional collaboration and cooperation (Madison 2012).

Smart City Visions

The cultural and political effects of older industrial Pittsburgh, while present in today's experience, are increasingly attenuated. Both its political and business elites and its community-based governance are gradually accepting and in many respects even trying to promote the transition to a postindustrial world. Pittsburgh is gradually becoming less of the place that it was, dominated by the ethos of industrial production, meaning large workforces making things, big companies, and benevolent corporate leaders, and more of a place that prioritizes best modern government and governance practices. A new political economic settlement has yet fully to emerge, but Pittsburgh's smart city investments are developing both as part of the transition and in its shadow.

Pittsburgh's emergence into its current smart city era is thus characterized by governance conditions both at the top of its political-economic hierarchy (elite

power and wealth) and at the community level (unusually strong micro governance) that coevolved with its twentieth-century model of highly integrated, concentrated industrial capitalism. In important respects, leadership styles and strategies have carried on as they did earlier in the twentieth century, planning from the top down for a new industrial future and now for a postindustrial future. Regional integration and collaboration along political, economic, or technological dimensions are almost entirely products of high-level public–private partnerships of the sort represented by the Allegheny Conference. The ACCD itself, with its affiliate and partnership organizations, remains a central participant in postindustrial coordination activities, along with other, more recently introduced organizations that focus explicitly on technology-themed sectors.

That synthesis means that Pittsburgh has no shortage of ambitious, even visionary plans for the city and region, plans that are now anchored in "innovation," "technology," and elements of the smart city. Often speculative and only partly realized in practice, they reflect a long-standing impulse to think from the top down in grand, urban, modernist terms, to sculpt the city to suit leaders' tastes and ambitions. These modern efforts signify less in terms of tangible results as to knowledge or data sharing and more in terms of Pittsburgh's continuing efforts to build and rebuild a certain mode of elite-led governance that is hierarchically conceived and technocratically implemented.

In 2014, Pittsburgh was a finalist in the national Smart City Challenge, a competition organized by the US Department of Transportation that awarded a $50 million grant to a public–private partnership focused on ambitious smart city pilot projects. That effort, called SmartPGH, was a collaboration among the City of Pittsburgh, Allegheny County, the Port Authority of Allegheny County, regional utilities, and leading philanthropies that focused on using smart technologies to reduce emissions from public and private transportation systems. Although the proposal was not successful in the Smart City Challenge itself, it catalyzed the formation of Metro21 at CMU and staked Pittsburgh's national reputation in smart city efforts.

The so-called p4 initiative was launched in 2015, "Pittsburgh for People, Planet, Place and Performance," rallying investors and philanthropies to projects highlighting the role of data in public administration, particularly in environmental, employment, and housing contexts. It aimed at making Pittsburgh a "city of the future" via urban growth and development coordinated through the Urban Redevelopment Authority, a public entity acting in coordination with the City of Pittsburgh. p4 later lost its alliterative title and became a City of Pittsburgh "City of the Future" initiative directed to environmental sustainability. Some of the development work undertaken in connection with p4 was rolled over into a "ForgingPGH" comprehensive visioning process that was intended to elicit community input via scenario planning. A parallel program, Pittsburgh's "Roadmap for Inclusive Innovation," included strategies to address Pittsburgh's digital divide, government data transparency, and technology-related entrepreneurship.

In 2017, the Brookings Institution think tank, on a commission from the City of Pittsburgh, leading Pittsburgh philanthropies, and leaders in Pittsburgh's high technology sector, delivered a report recommending that Pittsburgh commit to an integrated, leadership-driven economic development strategy to accelerate the region's transition to a technology-and-innovation-based economy (Andes et al. 2017). Pittsburgh's slow rebound from the end of the steel era had already attracted global attention; President Barack Obama called attention to it by arranging to host the 2009 Group of 20 meeting in Pittsburgh.

The Brookings Report prompted both the formation of a formal philanthropy-funded coordinating entity (InnovatePGH) and the launch of a regular series of leadership meetings, as to tech-centered development, among the mayor of the City of Pittsburgh, the presidents of the region's two leading universities (the University of Pittsburgh and CMU), leaders of Pittsburgh's largest philanthropic organizations, the County Executive (the elected leader of Allegheny County), and the head of UPMC Health Systems.

A similar coalition of public and private leaders, facilitated by the modern version of the ACCD, assembled Pittsburgh's proposal in 2018 to secure an Amazon headquarters facility, the so-called Amazon HQ2, as part of Amazon's national intercity competition for that prize. (By that time, the ACCD had expanded its mission and taken on an explicit ambition to serve as an ambassador for Pittsburgh business (Nunn and Rosentraub 1997).) Pittsburgh's bid was released publicly only long after Amazon chose another contender. The bid relied heavily on the collaborative culture that Pittsburgh's business and government elite built among themselves during the region's steel heyday.

More recently, in 2021 the City of Pittsburgh promoted the "OnePGH" plan, which aimed to link the city, the nonprofit community, and local philanthropies in efforts to promote affordable housing, green infrastructure, and workforce development, and a "2070 Mobility Vision Plan" that speculated about a hyperloop system, high-speed trains, aerial trams, vertical takeoff and landing vehicles, and an updated network of bridges. (Transportation is an important contemporary theme; 2021 also saw the release of a "Downtown Mobility Plan" by the Pittsburgh Downtown Partnership, an ACCD affiliate; a regional long-range plan produced by the Southwestern Pennsylvania Commission, and a NEXTransit plan spanning twenty-five years from the Port Authority of Allegheny County.) The Pittsburgh Robotics Network, an alliance of private industry and economic development organizations that took shape after the publication of the Brookings Institute Report in 2017, published a proposal in 2021 for $150 million in public funding of industrial research and development to accelerate the growth of Pittsburgh's robotics and autonomous technology sector. Last but by no means least, in 2021 the Richard King Mellon Foundation announced a commitment to donate $150 million, the largest grant in the foundation's history, to Carnegie Mellon University to support technology research initiatives directed to the community, and $100 million to

underwrite a new "BioForge" biotechnology manufacturing facility in Pittsburgh. The CMU funds are designated for supporting research and programming at the intersection of technology design and community engagement in Pittsburgh; the BioForge fund is aimed at catalyzing new commercialization efforts building on health sciences research at the University of Pittsburgh.

The Blossoming of Pittsburgh as a Smart City

In addition to these relatively grand plans, Pittsburgh's contemporary smart city investments have a variety of recent specific antecedents in both public and private sector technology deployments. Pittsburgh has never tried meaningfully to follow a plan regarding information technology, either as mode of government practice or as focus of economic development (Deitrick and Briem 2021). Its efforts have advanced on the ground at lower levels. Some present practices are traceable to initiatives from twenty years ago and before. The Pittsburgh Neighborhood Atlas, from 1977, was a significant early modern effort to build an information system for the city. Other key early smart city ventures are highlighted here.

Three of these focused on civic data and public administration in the City of Pittsburgh. The first, 3 Rivers Connect (3RC) (named for Pittsburgh's location at the confluence of three rivers), was a private nonprofit initiative launched in 1999, founded and operated by researchers connected to CMU, leveraging privately developed, venture capital-backed database, search, and visualization technology distributed in a pair of sister companies, MAYA Design and MAYA Viz. It was funded by Pittsburgh-based philanthropy. Characterizing itself as a venture in "civic computing," 3RC initially hosted a web-based resource titled the Information Commons, which consisted of an early online directory of community-based organizations and resources. The Information Commons evolved into an effort to develop search tools and data analytics that crossed traditional and fragmented data silos, linking information from and for public sector organizations, economic development interests, and community groups.

(Notably, this early investment in the immaterial, technocratic city emerged around the same time that the early internet materialized in a physical location. In 2002, the ground floor of the former Downtown headquarters of Alcoa was converted by a public–private regional government entity (the Pittsburgh Regional Alliance (PRA)) into a "technology information hub" called the Xplorion. The Xplorion featured banks of plasma screens displaying information for visitors about Pittsburgh-specific business development, education and training opportunities, and cultural attractions. Before the smart city was conceived as an immanent part of everyday life, a version of the smart city in Pittsburgh was a showroom that one could visit on foot, and that the PRA hoped would create a "wow" factor that would appeal to businesses considering whether to locate in Pittsburgh.)

As a use case for MAYA's technologies, 3RC itself grew in scope over fifteen years of operation, and it eventually developed and offered separate websites and software tools for both community and public sector application. 3RC not only inventoried resources across multiple sectors but also supplied tools for querying and analyzing data pools. Among its public sector partners was the Allegheny County Department of Human Services. The county's humanservices.net domain served as a gateway to an Information Commons repository of information about daycare centers, drug and alcohol assistance, and food banks, combined with mobility and access information for citizens. As commercial search technologies and accessible databases got larger and more powerful, the case for 3RC weakened, and it wound down in 2012. Its privately owned data analytics technology for civic infrastructure had already been spun forward into a separate commercial entity.

The second was implemented within the administration of the City of Pittsburgh during the tenure of Mayor Tom Murphy in the early 2000s. The system was CitiStat, a statistics tracking and data analytics system pioneered in the City of Baltimore, Maryland. The purpose of CitiStat was to centralize data collection as to forms of citizen/community interaction (citizen phone calls about city services, pothole filling, garbage collection, and so on) and then to allocate service-based resources accordingly. The system would help rationalize the distribution of those resources and create a data-based system for employee and managerial accountability. Pittsburgh's CitiStat system required a dedicated physical space where team members would meet to share and analyze data. The space was built, but the system did not survive the end of Mayor Murphy's administration in 2006.

The third, serving most directly as a precursor to contemporary smart city practice, was the Pittsburgh Neighborhood and Community Information System (PNCIS), which operated from 2005 to 2014 as an initiative of the Center for Economic Development at CMU and the University Center for Social and Urban Research (UCSUR) at Pitt. Beginning in 2008, PNCIS was as an affiliate of the National Neighborhood Indicators Project (NNIP), a national network of data intermediaries organized by the Urban Institute. PNCIS was an open data initiative, collecting and cleaning datasets addressing public and community activities in Pittsburgh and making them available for public access and use, either online or via hard computer media. It was funded partly by Pitt, partly by CMU, and partly by the City of Pittsburgh, with fundraising and management support from a Pittsburgh-based community financial organization, the Pittsburgh Partnership for Neighborhood Development (PPND) and local philanthropies. But the PNCIS was not funded sufficiently for its services to meet the full range of community need, and it was not charged with supporting public sector activities as well as community organizations.

The technical and structural limitations of PNCIS were recognized and addressed in the development of a successor open data enterprise, the Western Pennsylvania Regional Data Center (WPRDC), which is supervised by the same person who led the PNCIS, Robert Gradeck. The WPRDC is the official open data

repository of the City of Pittsburgh and accepts open datasets from all manner of regional governments and community organizations. It was created in 2014 via a collaboration among the City of Pittsburgh, Allegheny County, and local philanthropies. As noted earlier, a complementary open data ordinance was adopted by the City of Pittsburgh at the same time.

The impulse to collect and publish data as "indicators" of community well-being both preceded the WPRDC (and the PNCIS) and survives it. The Pittsburgh TODAY Regional Indicators project, housed separately at UCSUR, traces its origins to the mid-1990s and a regional benchmarking project initiated by the *Pittsburgh Post-Gazette*, the region's principal daily newspaper. The project originated in the newspaper's instinct to document the region's post-steel recovery in quantitative terms. The project has been sustained through organizational and funding changes, including management by 3RC, and continues today under the leadership of one of the journalists who helped launch the project in the first place. Public sector indicators projects have been less durable. A Pittsburgh Equity Indicators report was published by the City of Pittsburgh in 2018 and updated in 2019, describing economic conditions in Pittsburgh relative to gender, race, and income.

Two additional enduring early smart city investments turn up at Allegheny County, home of the Department of Human Services mentioned earlier, and in the private real estate development community.

Allegheny County created its Data Warehouse in 1999, consolidating its own internal data relating to behavioral health, child welfare, and homeless services in order to support decision-making, improve case management, and conduct policy analysis. The Data Warehouse is, in sum, an internal management tool. (The 3RC service was in part an early public-facing interface for certain data collected in the Data Warehouse.) Later, data from other county agencies were included, and the county crossed jurisdictional lines to partner with the Pittsburgh Public Schools, an unrelated public authority responsible for all public primary and secondary education in the City of Pittsburgh; with the Allegheny County court system and the Allegheny County Jail; and the housing authorities of both Allegheny County and the City of Pittsburgh. Cooperative agreements with other government organizations enable the county to conduct trend-based data analysis that links county-level data to human services data acquired both from the state of Pennsylvania and from the federal government.

The Data Warehouse was launched as part of a larger, comprehensive reorganization of the county's service departments, whose fragmented character was deemed to have contributed to the death of a child formerly in the charge of the county's child protection service. Funding for the project came from Pittsburgh-based philanthropies. In expanded and modified form, it is still in use today. In 2013, with data shared by the Pittsburgh Public Schools and other school districts in Allegheny County, and in coordination with the United Way of Southwestern Pennsylvania, Allegheny County launched a "Be There" campaign addressed to public school students,

premised on data-derived correlations between school attendance and the need for public services supplied by the county. (The United Way holds a large trove of data relating to demand for services provided by community organizations, as the provider of the "211" information hotline.) Since 2016, the Data Warehouse has supported DHS's use of its Allegheny Family Screening Tool (AFST), a predictive risk modeling tool for addressing allegations of child maltreatment. The AFST uses the content of the Data Warehouse to generate a "Family Screening Score" for each call to the county's child welfare hotline, predicting the long-term likelihood of a family's future involvement with child welfare systems. Call center staff use the score in determining which calls to refer to investigators.

Last among these early precursors to contemporary smart city practices in Pittsburgh is real estate development. A leading Pittsburgh philanthropy funded the formation of the Green Building Alliance (GBA) in 1997 as a nonprofit organization focused exclusively on environmentally friendly building practices in the region's commercial building sector. The GBA was the first such organization of its kind in the United States. Among the GBA's early successes was the new David L. Lawrence Convention Center, opened in 2003, which was awarded Gold LEED certification by the US Green Building Council. That project accelerated Pittsburgh's progress on the green building front, progress that is now linked directly to investments in smart building technology that renders the building's energy performance more data-driven and efficient. The GBA now operates a data collection and sharing program as Pittsburgh's "2030 District" (part of a network of "2030 Districts" around the world, a spinoff of the private Architecture 2030 advocacy organization). That program enables GBA members to collect and share data on building performance with one another and with the City of Pittsburgh.

In 2016 and again in 2019, the City of Pittsburgh added formal endorsements to these private sector efforts. The Pittsburgh Building Benchmarking Ordinance, adopted in 2016, requires owners of large nonresidential buildings to report their annual energy and water consumption to Pittsburgh. In 2019, the City of Pittsburgh adopted an ordinance that requires that all new or renovated Pittsburgh government buildings be net-zero (NZE) ready. The GBA works closely with the real estate development efforts of Pittsburgh's Urban Redevelopment Authority (URA) and with energy planning initiatives in Pittsburgh's commercial neighborhoods, and it partners with the CREATE Lab at CMU to develop "democratizing data" programs. Those efforts are aligned with the City of Pittsburgh's Climate Action Plan, the first version of which was adopted in 2008. (Version 3.0 was released in 2018 following an extensive process of community engagement.) Arguably, even Pittsburgh's legacy industrial producers are starting to get environmentally "smart" and to follow the trend toward cleaner air. In early 2021, US Steel announced that it canceled a planned $1 billion investment in emission control and production upgrades at its remaining operations in the Monongahela Valley, upriver from Downtown Pittsburgh. Instead, three batteries at the Clairton Coke Works, long the source of

much of Pittsburgh's worst particulate pollution, will be shut down. The company's decision drew immediate and loud public recriminations from a coalition of labor unions.

PITTSBURGH'S SMART CITY SOLUTIONS

With the inauguration of Mayor Peduto in early 2014, the pace and breadth of new and extended smart technology systems in Pittsburgh and related technology-oriented developments increased. Likewise, their salience increased both within public administration processes and in public-facing conversations about the roles of technology in Pittsburgh society. This section catalogs continuing smart city projects in Pittsburgh. The catalog illustrates both data-sharing practices as knowledge commons, in which data is collected and pooled as a shared resource, and governance-sharing practices as a distinct form of knowledge commons, in which governance techniques and strategies are combined across formal organizations. The catalog is offered here primarily for its potential utility for further research.

Key observations ease the way into presenting the catalog itself.

Smart City Accelerants and Catalysts

Critical players and contributors to the post-2014 transition came from a variety of sources. The mayor himself stands out, though the power of his administration to move forward with smart city strategies depended in part on the fact that its interest in doing so coincided with broader national and international interest in technology- and data-based public administration, the availability of relevant technology, and political and cultural transitions in Pittsburgh.

The most important of these transitions was the new administration's decision to create a new Department of Innovation and Performance in 2014 and a new Department of Mobility and Infrastructure in 2017. "Innovation and Performance" fulfilled a campaign pledge to modernize city administration with new technologies and practices. It is both a service center for other City of Pittsburgh departments and a coordinator of relationships with technology vendors and academic partners. Its inaugural director, Debra Lam, served in Pittsburgh until 2017, when she left to become Managing Director, Smart Cities and Inclusive Innovation at the Georgia Institute of Technology (Georgia Tech). "Mobility and Infrastructure" (DOMI) grew out of the priority assigned to modernizing Pittsburgh's transit and transportation systems in connection with the city's economic development goals.

Mayor Tom Murphy, who served the City of Pittsburgh between 1994 and 2006, was similarly inclined toward the uses of data and technology. But his constituency was not prepared to support a technocratic vision of Pittsburgh government, and the relevant technology was in its infancy, comparatively speaking. Murphy's successor and Peduto's predecessor, Luke Ravenstahl, exhibited little enthusiasm for a

technology-first approach. Municipal finances compounded political and ideological barriers. In 2003 the City of Pittsburgh designated itself "distressed" under Act 47, the rough equivalent of municipal insolvency under Pennsylvania law. Tax reform and restructuring Pittsburgh's pension system were high priorities. Pittsburgh exited Act 47 status in 2018.

Political leadership played only one role in the shift toward a more aggressive embrace of smart technologies. Pittsburgh's smart city deployments emerged and continue to operate as complex combinations of contributions from the public sector, the philanthropic sector, local universities, private technology companies, and occasional key interventions by specific individuals. Pittsburgh's institutional and organizational resources were summarized earlier. Additional resources partly constitute a loose network of cultural capital and partly enhance Pittsburgh's pool of smart city expertise directly.

At the micro level, individual actors have at times played important parts in building and sustaining Pittsburgh's contemporary technology practices. Their contributions can be traced partly to their institutional identities or affiliations and partly to their personal and professional mobility from role to role and sometimes from sector to sector, as catalysts, relationship builders, and endorsers. For example, the Allegheny County Data Warehouse was launched as part of a large reorganization of service provision by the county that included the creation of the Department of Human Services itself. The reorganization was recommended by a blue ribbon commission led by John Murray, president of Duquesne University, former dean of the law schools at both Duquesne and the University of Pittsburgh, and a widely respected community presence. The early success and longer durability of the Data Warehouse is credited both to the director of that department, Marc Cherna, and to the talent of the person later hired to expand and extend it, Erin Dalton. The success of the Western Pennsylvania Regional Data Center is partly attributable to the efforts of its director, Robert Gradeck, who helped to found and operate its predecessor organization, PNCIS, as a staff member at CMU's Center for Economic Development. The smart cities partnership between the City of Pittsburgh and Carnegie Mellon University leaned on the experience of Richard Stafford, who directed the launch of Traffic21 in 2009 and Metro21 in 2014 and who served as the Chief Executive Officer of the ACCD from 1990 to 2003. Key individuals at Pittsburgh's three leading philanthropic organizations have played important roles from time to time in brokering new institutional designs in Pittsburgh's uses of public technology.

At the macro level, the City of Pittsburgh taps relationships with Results for America, a national nonprofit supporting data-based public administration and funded by Bloomberg Philanthropies; the Operational Excellence initiative and the Government Performance Lab at Harvard University, part of the Ash Center for Democratic Governance and Innovation at Harvard's Kennedy School; and the Center for Government Excellence (GovEx) at Johns Hopkins University.

Pittsburgh public administrators have been active in the Civic Analytics Network, a cohort of public data officers hosted by Harvard's Ash Center. Metro21 at CMU spawned the MetroLab Network, a network of city–university partnerships, in 2015, as part of the White House Smart Cities Initiative.

A Smart City Catalog

Six tables of smart city initiatives in Pittsburgh follow, representing a portrait of contemporary Pittsburgh as a smart city disassembled into many of its constituent parts.

Any catalog inevitably raises classification and clustering challenges; here, those challenges are compounded by the fact that this chapter takes smart city practice to include a broad range of systems and practices. Lots of things count as smart city-related initiatives in Pittsburgh for my purposes, in the sense that lots of things are worth examining in greater detail as cases of knowledge commons governance. But they count in different respects. The classifications used below are provisional. The knowledge commons governance in evidence may be sorted differently by other researchers.

Table 6.1 lists resources and systems that constitute all or parts of smart city infrastructure. These are mostly technical systems for network connectivity and data storage, which offer the means to collect data, to combine or pool data, to access data, or some combination of the three.

Table 6.2 lists resources for providing citizen access to public decision-making processes, via one or more technological means. These include mobile applications for requesting public services or public information; technology platforms that provide levels of transparency with respect to public administration processes; and technology-reliant systems for soliciting community input into public decisions.

Table 6.3 lists technology-based systems for collecting data about citizen behaviors and community resource conditions, many of which recirculate that data into decision-making processes within public administration systems.

Table 6.4 lists systems for "smart" decision-making by public authorities, consisting mostly of algorithmic processes that rely on data from a variety of sources. The line between "data governance" and "algorithmic decision-making" is fine and, in practice, possibly nonexistent.

Table 6.5 lists areas where technology development and deployment are parts of Pittsburgh's public sector engagement with smart city strategies in unusual or unorthodox respects: recreation and education, on the one hand, and economic development in the private sector, on the other.

Table 6.6 lists instances of smart city practice in Pittsburgh that emanate in the first place from community engagement with community needs, in identifying problems and developing data- and technology-development strategies as governance solutions.

TABLE 6.1. *Infrastructure*

Item	Sector	Technology or system	Initiators, providers, funders	Date launched	Notes (purposes, legal frameworks, outcomes)
1	Connectivity – broadband	Connectivity Improvement Plan for the Western Pennsylvania region	Southwestern Pennsylvania Commission; Metro21 and Traffic 21 at Carnegie Mellon University; and Allies for Children (a Pittsburgh nonprofit funded by the United Way, among other grantors)	Announced in 2021	Map, gap analysis, and strategic plan intended to guide improvement of regional broadband connectivity in relation to demographics, socioeconomic conditions, educational, health care, and business needs.
2	Connectivity – networking	NetPGH	City of Pittsburgh Department of Innovation and Performance and a proposed commercial vendor	Announced in 2020	Initiative intended to support single-provider fiber connectivity network among city facilities.
3	Storage	Google Cloud	City of Pittsburgh Department of Innovation and Performance and Google Cloud	Contract awarded in 2020	Project that migrates to Google Cloud existing applications and datasets (including the city's website, its GIS data, its permitting system, and its security camera system) from on-premises VMWare storage.
4	Devices	Computer hardware and related systems	City of Pittsburgh Department of Innovation and Performance; Dell Technologies	2019	The City of Pittsburgh selected a single vendor to supply and upgrade desktop, laptop, and mobile devices with the expectation that they would be used by City employees in implementing smart city programs, such as the Snow Plow Tracker (Table 6.2, item 1) and the Rec2Tech program (Table 6.5, item 1).
5	Analytics	City Performance Tool (CyPT)	City of Pittsburgh Office of Sustainability; Siemens; the Green Building	Partnership announced in 2017; report	The tool supports decision-making as to physical infrastructure in the public sector, focused on carbon dioxide emissions associated with energy

(*continued*)

TABLE 6.1. (*continued*)

Item	Sector	Technology or system	Initiators, providers, funders	Date launched	Notes (purposes, legal frameworks, outcomes)
			Alliance, the Hillman Family Foundations, Carnegie Mellon University, the University of Pittsburgh, regional utility suppliers, and the National Energy Technology Laboratory (NETL, with a site located in Pittsburgh)	produced in 2019	generation, building design, transportation, and economic development.
6	Management – organization and service delivery	Information Technology Infrastructure Library (ITIL) training and certification in best practices in information technology (IT) services	City of Pittsburgh Department of Innovation and Performance; Axelos (a commercial provider of training and certification standards for best practices methods in IT services); New Horizons (a commercial provider for ITIL training)	2018	ITIL training was introduced to improve and systematize and integrate IT operations and service delivery across City of Pittsburgh departments and to city residents.
7	Platforms – open data	Western Pennsylvania Regional Data Center (WPRDC), hosting datasets including data generated via	Heinz Endowments (funder); Allegheny County (grantee); City of Pittsburgh (grantee); University of Pittsburgh (grantee, host, and funder)	2015	With respect to the City of Pittsburgh, the WPRDC fulfills the city's obligation by ordinance adopted in March 2014 to provide public access to municipal datasets. With respect to other public bodies, particularly Allegheny County, the WPRDC makes available certain datasets that in the judgment of the WPRDC adequately protect privacy interests of data subjects. The WPRDC also engages with local and national community organizations in developing and

		the City of Pittsburgh and Allegheny County			distributing open datasets and providing data literacy education, notably the National Neighborhood Indicators Partnership (NNIP) and the Black Equity Coalition.
8	Datasets – data pools	Allegheny County Data Warehouse	Allegheny County Department of Human Services (DHS) (host); the Human Services Integration Fund (a coalition of Pittsburgh foundations) (funders); the Allegheny County Office of Data Analysis, Research, and Evaluation (manager)	2000	The Data Warehouse and the DHS itself were elements of a large-scale restructuring of Allegheny County government and services recommended by a volunteer-based blue-ribbon commission, the Independent Committee to Review Allegheny Children and Youth Services, aka the Murray Commission.
9	Decision-making tools – data dashboards (public-facing) and complementary dashboards (internal to the City of Pittsburgh)	Burgh's Eye View dashboards and visualizations; Dashburgh	City of Pittsburgh Department of Innovation and Performance	Burgh's Eye View: 2016 Dashburgh: 2021	Burgh's Eye View map-based dashboards are created from data generated by 311 requests for city services, public safety information, building information, city resource inventory, tax delinquent properties, and traffic signal information. Dashburgh, a dashboard for accessing dashboards, was launched in December 2021.
10	Decision-making tools – digital twins	Virtual twin dataset	City of Pittsburgh; Allvision (a technology startup based in Pittsburgh)	2020	Allvision participated in the PGH Lab program (item 15 below) and piloted a virtual twin program to create an inventory of City of Pittsburgh streetlights (used both for lighting and telecom infrastructure), using LIDAR and GPS technology.
11	Decision-making tools – mobility and accessibility	AgileMapper	Various municipalities in Western Pennsylvania	2016	AgileMapper is supplied by RoadBotics, a Carnegie Mellon University spinout company that offers technology for producing mapped visual asset data

(*continued*)

TABLE 6.1. (*continued*)

Item	Sector	Technology or system	Initiators, providers, funders	Date launched	Notes (purposes, legal frameworks, outcomes)
					of a community's physical assets, primarily road conditions (degraded streets, including potholes), by distributing data collection in a smartphone app.
12	Decision-making tools – land banking	Land Bank	City of Pittsburgh Urban Redevelopment Authority (URA)	2014	The Pittsburgh Land Bank was created as an independent municipal agency in 2014 to inventory roughly 11,000 parcels of vacant, abandoned, and distressed real estate and return it to productive use. The program has largely failed to meet its goals, in part because many parcels are burdened with tax liens owned by other government entities, and in 2021 it was moved into the URA, a long-standing municipal agency charged with coordinating economic development activity based on publicly owned real estate. Pittsburgh efforts to compile data regarding vacant and abandoned property date to 2000 and include community efforts coordinated through the University of Pittsburgh Community Outreach Center (COPC) and the Pittsburgh Community Reinvestment Group's Vacant Property Working Group. Those efforts later merged into the formation of the Pittsburgh Neighborhood and Community Information System (PNCIS), founded by CMU and the University Center for Social and Urban Research (UCSUR) at the University of Pittsburgh. Public and community efforts to manage Pittsburgh's vacant land also include the Vacant Lot Toolkit (2015) and the related Adopt-A-Lot Ordinance, adopted by the

					City of Pittsburgh; and investments of time and volunteer expertise by community organizations that include Tree Pittsburgh, Grow Pittsburgh, the Pittsburgh Greenspace Alliance and the Western Pennsylvania Conservancy, a public/private partnership.
13	Decision-making tools – waste management	Smart trash cans	City of Pittsburgh Department of Public Works	2019	The City of Pittsburgh deployed 1000 smart trash cans equipped with sensors to indicate their quality of functionality (damaged, afire) and level of fullness.
14	Decision-making tools – wastewater and stormwater management	Sewer line and tunnel inspection via the RedZone Solo robot and Multi-Sensor Inspection (MSI) systems	City of Pittsburgh and Pittsburgh Water & Sewer Authority; ALCOSAN (Allegheny County Sanitary Authority); RedZone Robotics (a technology startup based in Pittsburgh)	2014	RedZone Robotics is a Carnegie Mellon University spinoff company.
15	Technology development	PGH Lab	City of Pittsburgh Department of Innovation and Performance	2016	The City of Pittsburgh operates this incubator for Pittsburgh-based smart technology companies to develop technology for piloting in the City of Pittsburgh and other local authorities. Priority for admission to the incubator is given to firms owned by members of underrepresented communities.

TABLE 6.2. *Citizen access to public processes*

Item	Sector	Technology or system	Initiators, providers, funders	Date launched	Notes (purposes, legal frameworks, outcomes)
1	City-provided public services	Citizen apps	City of Pittsburgh	Various	Citizen-facing app-based information about public services includes: Snow Plow Tracker; PGH.st (trash schedule); Snow Angels (crowdsourced community-based snow removal); One Stop PGH (integrating information about planning applications and building permits, code enforcement, and business licensing); and CivicCentral (formerly BuildingEye) (database access for the City of Pittsburgh Department of Permits, Licenses, and Inspections). Citizen-facing app-based payments systems include mechanisms regarding: parking tickets and parking leases (in municipal garages and lots), and OneTaxPGH (business and real estate taxes). Citizen-facing app-based registration systems include mechanisms for: fire/burglar alarms and public facility use. Citizen-facing app-based data input mechanisms include: PGH Watchdog (for submitting claims about waste and theft of city property and services, supplementing the 311 system for submitting citizen requests for service); and Engage PGH (dashboard of city-sponsored planning projects soliciting public input).
2	Government procurement	Beacon	City of Pittsburgh Office of Management and Budget (host); Code for America (technology development); the R. K. Mellon Foundation (funder)	2016	Beacon and the Beacon website consist of a public-facing database of public contracts and Calls for Bids (CFBs).

3	Municipal finance	Open Book Pittsburgh	City of Pittsburgh Office of the City Controller	2009	Open Book Pittsburgh consists of a database and dashboard providing information regarding municipal contracting, campaign finance contributions and expenditures, lobbyist identities, and financial disclosures by public officials.
4	Municipal finance	Fiscal Focus Pittsburgh	City of Pittsburgh Office of the City Controller	2015	Database and dashboard providing information regarding municipal budgeting and payments.
5	Citizen input into government decision-making	Potholes and Pierogies	City of Pittsburgh Mayor's Office of Community Affairs	2018	The City of Pittsburgh organized deliberative forums for residents on the city's capital budget, hosting the events in neighborhoods and at times intended to maximize access. The name "Potholes and Pierogies" is both a reference to the dinner menu and a nod to the many Pittsburghers descended from immigrants.
6	GIS data; physical infrastructure	Who Owns My Infrastructure?	Allegheny County Geographic Information Systems (GIS) Team	2018	The website consists of a data visualization that uses Allegheny County GIS data and data from the WPRDC (Table 6.1, item 7), and the Pennsylvania state Department of Transportation and Department of Environmental Protection.
7	Public health	Opioid Overdose Dashboards	City of Pittsburgh Department of Public Safety; Allegheny County Health Department (separate dashboards)	2021	The City of Pittsburgh dashboard compiles data from EMS service calls for opioid overdoses on a monthly basis and maps that data to demographic and neighborhood-level information. The Allegheny County dashboard relies on overdose death data from the Allegheny County Office of the Medical Examiner (ACOME), Emergency Departments, and EMS agencies.

TABLE 6.3. *Public ICTs for citizen utility*

Item	Sector	Technology or system	Initiators, providers, funders	Date launched	Notes (purposes, legal frameworks, outcomes)
1	Mobility and accessibility	Surtrac	City of Pittsburgh Department of Mobility and Infrastructure; Carnegie Mellon University (initial technology partner); Rapid Flow Technologies (a technology startup based in Pittsburgh)	2012	Surtrac technology for traffic control via smart traffic signals was developed at Carnegie Mellon University, piloted in the City of Pittsburgh, and later spun out into a private company, Rapid Flow Technologies. Rapid Flow Technology has expanded its partnership by deploying the technology elsewhere in the City of Pittsburgh as part of a city-led "Smart Spines" project for traffic flow along several priority corridors. The City of Pittsburgh also receives aggregated traffic flow data from the private mobility company Waze and from the I-95 Corridor Coalition Traffic Flow Data Program.
2	Mobility and accessibility	Sidewalk accessibility	City of Pittsburgh Department of Mobility and Infrastructure; Port Authority of Allegheny County (a county authority); Pittsburgh Parking Authority (a municipal authority); University of Pittsburgh (initial technology partner); pathVu (technology partner)	2017	pathVu is a commercial company spun out of the University of Pittsburgh that collects data about sidewalk conditions via both crowdsourced and automated inputs. The company was a member of the PGH Lab program (Table 6.1, item 15).
3	Mobility and accessibility	Parking	City of Pittsburgh; Pittsburgh Parking Authority; Parkmobile (a national technology company, vendor to City of Pittsburgh);	2014	Coin-operated parking meters throughout the City of Pittsburgh were replaced by digital kiosks, accessible by smartphone; payments are managed through Parkmobile, a commercial vendor, and Meter Feeder, a Pittsburgh-based rival. The Pittsburgh Parking Authority uses license plate recognition equipment on roving vehicles to monitor parking in the City of

			Meter Feeder (a technology startup based in Pittsburgh, vendor to the City of Pittsburgh and other municipalities in the region)		Pittsburgh. Meter Feeder also provides parking payment services to other Pittsburgh-area municipalities.
4	Mobility and accessibility	Pitt Smart Living Project	University of Pittsburgh	2019	University of Pittsburgh researchers used funding from the National Science Foundation and a partnership with Walnut Capital (a private real estate developer) to develop facilities that supply data to public transit users, combining data from the Port Authority of Allegheny County, public weather data, and information about crowding in stores and other places obtained from Google Place). The purpose of the project is to encourage prosociality and to reduce public transit congestion by combining and sharing information about transit use with information about business resources (inventory, time-sensitive pricing).
5	Mobility and accessibility	Move PGH	City of Pittsburgh Department of Mobility and Infrastructure; Port Authority of Allegheny County; private micromobility providers (technology partners); R. K. Mellon Foundation (funder)	2021	Move PGH is the product of a community convening begun in 2019 titled the Pittsburgh Micromobility Collective ("Mobiliti"). The initiative centers on a "Mobility as a Service" ("MaaS") pilot project and includes the "Transit" app and Ready2Ride, systems that permit City of Pittsburgh residents to pay bus fares, rent micromobility vehicles such as electric bikes and scooters, find carpool partners, and rent vehicles for short-term use. Private micromobility partners are given exclusive operating rights in the city for two years and will maintain fifty "mobility hubs" near existing transit stops to support electric bikes and scooters, including real-time light rail and bus information on digital screens. State law was amended to permit e-scooters to operate under the motor vehicle code. The Port Authority distributes real-time route and schedule data via TrueTime and Bus Tracker applications.

TABLE 6.4. *Public ICTs for data-based decision-making*

Item	Sector	Technology or system	Initiators, providers, funders	Date launched	Notes (purposes, legal frameworks, outcomes)
1	Public safety and policing	Automated License Plate Readers	Allegheny County District Attorney; OpenALPR (technology provider)	2017	Community concern about the ALPR systems in Pittsburgh and the unsupervised use of the systems by the Allegheny County District Attorney was raised in 2019 in Pittsburgh media, by national civil liberties organizations, and in the state legislature.
2	Public safety and policing	Surveillance cameras	Allegheny County District Attorney and the Allegheny County Chiefs of Police Association	2017	County officials and police departments outside the City of Pittsburgh installed a network of security cameras in fifty locations, including in some City of Pittsburgh neighborhoods, to capture footage potentially relevant to street crime.
3	Public safety and policing	Pre-trial Risk Assessment Tool	Allegheny County Municipal Court	2016	A unit of the court makes recommendations regarding pre-trial release conditions for criminal defendants. The recommendation relies on a risk score, which is determined by a risk assessment tool and based on personal interviews and other information.
4	Public safety and policing	ShotSpotter	City of Pittsburgh Bureau of Police; ShotSpotter (technology provider)	2018	ShotSpotter technology uses acoustic sensors to identify and characterize gunfire and automatically notify emergency responders via the 911 service.
5	Public safety	Pedestrian Safety Action Plan	City of Pittsburgh Department of Mobility and Infrastructure	Plan released 2021	The plan proposes to conduct data-based Road Safety Audits to analyze and treat areas of historical and predicted pedestrian crashes.
6	Public health – family welfare	Allegheny Family Screening Tool (AFST)	Allegheny County Department of Human Services; R. K. Mellon Foundation (funder)	2016	The AFST is a predictive modeling tool designed to improve child welfare screening decisions. The AFST relies on the data collected in the Allegheny County Data Warehouse (Table 6.1, item 8).

7	Public health – child welfare	Hello Baby	Allegheny County Department of Human Services; various nonprofit organizations (partners); the Heinz Endowments (funder)	2020	Hello Baby is a data-based tiered prevention model for allocating public health and child support resources on a voluntary basis to families with children under age three. Hello Baby relies on data collected in the Allegheny County Data Warehouse (Table 6.1, item 8).
8	Education	Be There	Allegheny County Department of Human Services; University of Pittsburgh; United Way of Southwestern Pennsylvania; Pittsburgh Public Schools; Congress of Neighboring Communities (twenty other public school districts in Allegheny County); Allegheny County Intermediate Unit; various philanthropies and nonprofits, including Allies for Children	2013	Public school districts in Pennsylvania are separate from municipal and county authorities. Be There was a public campaign to encourage school attendance developed as a result of a voluntary data-sharing partnership established initially in 2011 between Allegheny County and the Pittsburgh Public Schools, with encouragement from the United Way of Southwestern Pennsylvania. Data from the Pittsburgh Public Schools and other school districts regarding attendance records and academic outcome data were combined with data on service provision to children, in the Allegheny County Data Warehouse (Table 6.1, item 8). Related voluntary data sharing among public school districts in Southwestern Pennsylvania is coordinated by the Remake Learning network, a nonprofit organization.
9	Environment	Air Quality Forecast and Dispersion outlook report	Allegheny County Health Department	2018	This dashboard was a relaunch of an existing resource, now anchored in Allegheny County Mon Valley Air Pollution Episode regulations. Air quality in Allegheny County has been a source of long-standing public and community concern, going back well over 100 years. Contemporary community activism dates to the formation of GASP (Group Against Smog and Pollution) in 1969 and now includes the Breathe Collaborative of nonprofit and research organizations and philanthropies.

(*continued*)

TABLE 6.4. (*continued*)

Item	Sector	Technology or system	Initiators, providers, funders	Date launched	Notes (purposes, legal frameworks, outcomes)
10	Environment	Street Tree Inventory	Western Pennsylvania Conservancy (a public/private partnership); Tree Pittsburgh; City of Pittsburgh Department of Innovation and Performance; the Pittsburgh Shade Tree Commission; UrbanKind Institute; Carnegie Mellon University	2014	This inventory is part of the TreeVitalize Pittsburgh project and includes a Street Tree Management Plan, an Equitable Street Tree Investment Strategy, and an iTree Eco Analysis.
11	Environment	Trees N'At	City of Pittsburgh	2018	A web-based mapping application built by the Department of Innovation and Performance, using satellite imagery to document the locations of all of Pittsburgh's street and park trees. The mapping application is linked to tree inventory data maintained by the Forestry Division of the Department of Public Works, stored in a Cartegraph database along with inventories of other city assets: city facilities, bridges, pools, playgrounds, rinks and fields, signs, crosswalks, and other geographic data. The datasets are shared via the WPRDC.
12	Food security	Optimizing food delivery via community organizations	Carnegie Mellon University; United Way of Southwestern Pennsylvania; Allegheny County Department of Human Services; Penn Hills School District; Municipality of Penn Hills; Greater Pittsburgh Food Bank	2020	This pilot project optimized bus routes for delivery of free breakfast and lunch to students in Penn Hills, a Pittsburgh suburb, by using anonymized data from the Allegheny County Data Warehouse about students and families receiving food services. The project built on an earlier effort to use student location data to optimize daily transportation services for children attending schools in Allegheny County.

TABLE 6.5. *Public support of ICTs in education and business*

Item	Sector	Technology or system	Initiators, providers, funders	Date launched	Notes (purposes, legal frameworks, outcomes)
1	Culture, recreation, and sociality	Rec2Tech	City of Pittsburgh; Comcast; Remake Learning (a Pittsburgh nonprofit); national and local philanthropies (funders)	2016	Public recreation facilities in the City of Pittsburgh host technology (STEM) learning events for young people. The program continued in 2020 with a grant from National Science Foundation to support Rec2Tech centers in Pittsburgh and Baltimore.
2	Economic development	Autonomous vehicle development	City of Pittsburgh Office of the Mayor; Uber, Argo, Aurora, Motional, Waymo (companies developing autonomous vehicle technology)	2016	Mayor Bill Peduto welcomed autonomous vehicle development and testing in the City of Pittsburgh by Uber and other firms in 2016 as part of an economic development strategy to attract robotics firms to the city. Pennsylvania law put no regulatory restrictions on self-driving cars on public streets. Following accidents involving Uber vehicles in other locations, Uber's failure to demonstrate public benefits associated with use of its autonomous vehicles or expansion of its business, and Uber's eventual exit from the autonomous sector, the mayor and the City of Pittsburgh suspended their embrace of autonomous vehicles on public streets and shifted to supporting real estate development at the site of a former steel mill, where autonomous vehicles could be tested on a private track. Labeled "Hazelwood Green," the project attracted public criticism because it required public subsidies for transit links between the site and the campuses of Carnegie Mellon University and the University of Pittsburgh. Building those links would disrupt an existing low- and middle-income neighborhood.

TABLE 6.6. *Community data production*

Item	Sector	Technology or system	Initiators, providers, funders	Date launched	Notes (purposes, legal frameworks, outcomes)
1	Housing	Eviction Rapid Response	Carnegie Mellon University; RentHelpPGH (partner); Heinz Endowments (funder)	2020	The project was developed in the CREATE Lab at Carnegie Mellon University (Community Robotics, Education and Technology Empowerment Lab), part of the Robotics Institute at CMU. Volunteers scrape local court websites to gather information about eviction filings and hearings, using the data to advise tenant and link them to community resources via the RentHelpPGH project and platform.
2	Environment	Smell PGH	Carnegie Mellon University; various regional and state nonprofits (partners); Heinz Endowments (funder)	2016	The project was developed in the CREATE Lab at Carnegie Mellon University. The app enables residents of Allegheny County to submit reports related to pollution odors.
3	Environment	Light Pollution Map	Pittsburgh section of the Pennsylvania chapter of the International Dark-Sky Association (IDA) and Carnegie Mellon University. Street light upgrades are being advanced by the City of Pittsburgh Department of Mobility and Infrastructure	2017	Pollution mapping was undertaken by aerial surveillance. In 2018, the City of Pittsburgh solicited bids for upgrading its inventory of streetlights with "smart" LED lights but abandoned the project because the city lacked the ICT infrastructure to support light fixtures as networked devices. In May 2021, Pittsburgh issued a call for proposals to upgrade all of its streetlights to non-networked LED fixtures. The City of Pittsburgh enacted a Dark Sky Lighting ordinance in August 2021. Pittsburgh's review of the effects of streetlights includes observations in 2010 by CMU's Remaking Cities Institute of glare emitted by early LEDs.

4	Civic technology	Community groups and projects that have focused on technology development for the civic sphere	Volunteers supported in part by the City of Pittsburgh, Urban Redevelopment Authority, Google, local philanthropies, and Civic Champs, a volunteer management software platform	2013	Volunteer-based organizations come and go, sometimes coalescing into formal nonprofit organizations and sometimes fading with the exit of key volunteers. A partial inventory of Pittsburgh civic technology groups includes Code for Pittsburgh (Pittsburgh's cohort in Code for America), Steel City Codefest, Remake Learning, and Google Civic Innovation.
5	Social justice	Data 4 Black Lives	Volunteers led by graduate students at CMU	2020	Pittsburgh-specific hub of a national nonprofit organization, Data 4 Black Lives (D4BL), that aims to identify and eventually abolish uses of Big Data systems that disproportionately affect Black residents and other people of color.

EVALUATION AND IMPLICATIONS

The GKC framework calls for evaluation of knowledge commons governance cases but doesn't specify particular standards or metrics. The following discussion draws out certain salient themes, focused in part on smart city governance themes and in part on knowledge commons themes. Inevitably, the discussion emphasizes questions for further research at least as much as it describes Pittsburgh's smart city failures, successes, challenges, and opportunities.

Does It Work?

The first and immediate question posed by any knowledge commons system and thus by a smart city governance system is whether it works. Does the system do what it is intended to do? What is it designed to do? What are its expected and unexpected costs and benefits, over different time scales? Does the system solve the problem that it is intended to solve, and does it solve a problem that needs to be solved? Does it create further problems either within its context or sector or by triggering spillover impacts elsewhere? These are not problems of knowledge commons governance or smart city technology as such. They are questions to be asked with respect to any institutional governance arrangement, and often to be asked in comparative context. How does the system work compared to one or any other actual or possible system?

Here, judgments are necessarily incomplete. Smart city practice may be motivated and influenced by ideals of effective and efficient governance, by conscious and subconscious idealization of technocratic control of urban spaces, and/or by the quest for better lives for city residents. On the ground, the question concerns the pragmatics of balancing individual and community interests, demands, and goals with available time, expertise, and material resources.

Pittsburgh's smart city governance is flawed at least in part in the sense that some data-driven systems have been pursued or deployed without adequate consideration being given to the need to invest in complementary technologies or labor to sustain them, particularly in a highly decentralized technical configuration. Labor and expertise demands have been revealed both with respect to data analytics, statistics, and network engineering and also with respect to field-based technicians. Asking garbage collectors to carry mobile tablets to record images of potholes means reconfiguring how garbage collectors are trained and how garbage trucks are crewed. Smart street lights can't necessarily be maintained by the same technicians who maintained older street lights.

Most of Pittsburgh's smart city systems are too new to have been subjected to much independent review of their efficacy or effects. The Allegheny County Department of Human Services has allocated resources to producing products that assess its uses of data analytics, which are thoughtful but which are not designed to undertake comprehensive comparative institutional analysis.

Emerging descriptive research has been directed to sector-specific uses of data and algorithms in Pittsburgh governance, focusing on land use (Ghosh, Byahut, and Masilela 2019) and the origins of Metro21 at CMU (Preis 2019). Some interviewees acknowledged that Pittsburgh's use of citizen-facing technologies such as dashboards has been more complete and effective than its use of data for internal decision-making. The WPRDC is widely known in Pittsburgh and elsewhere as a model of an open data institution, but it has engaged in relatively little community outreach in Allegheny County. As noted earlier, critical approaches mostly focus on the Allegheny County AFST (Eubanks 2019) and on the uses of algorithms in public decision-making in Allegheny County.

Looking at smart city governance as an element of Pittsburgh's broader turn toward technology-driven economic development, the evidence of impact is mixed, both for better and for worse, and mostly incomplete. As with many cities, Pittsburgh often focuses on metrics that are at best imprecise, such as total dollars invested in private sector technology companies and the aggregate number of associated jobs, and at worse misleading. It is plausible to hypothesize that recent developments in Pittsburgh's reliance on technology-based firms, and Pittsburgh's interest in an "innovation economy," have grown despite rather than because of coordinated or planned efforts to advance such a technocentric vision.

Experts and Expertise

Commons governance of all sorts, but especially knowledge commons, leans heavily on questions of boundaries and boundary making. Because both knowledge resources and governance resources are largely immaterial, the character of resource boundaries – including organizational and community boundaries – involves historical accident as well as institutional design, public policy choice, and logical or conceptual clarity. What Sassen refers to as *borderlands* are often the most interesting and important governance topic to explore (Sassen 2001). Few borderlands questions are as fraught, conceptually or empirically, as the question of experts and expertise in collective, community governance. The history of research science and scholarly communications, perhaps the canonical examples of knowledge commons governance through time, illustrates precisely how the role of experts and expertise has to be explored carefully in the context of broader social and community goals (Boyle 2006; Kuhn 1996).

The key conceptual point, to be developed through further research, is that people working with data are almost of necessity members of functional expert communities, practicing an emergent form of knowledge commons. Community boundaries are necessarily porous; community membership is necessarily fluid. Expertise in the smart city, including Pittsburgh's smart city, is a process of becoming, not a state of being.

The Pittsburgh smart city experience makes clear the roles of both technical expertise as to data and information technology and public policy expertise as to the

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uses of data in public administration and community engagement. It makes clear that those roles did not always predate the development and deployment of a range of smart city systems and strategies. Roles and their responsibilities grew and evolved over time, and the people themselves moved about the system for a variety of reasons.

Community-based expertise of this sort appears to be the hinge that distinguishes exploration of smart city practice as knowledge commons from the premise that knowledge commons governance proceeds from nuanced understanding of the role of openness in a resource management system. An emphasis on expert knowledge and expert networks, long a creature of Progressive politics (and thus dating to Pittsburgh's earliest efforts to acquire data about itself), is in tension with that premise. As criticism of the Progressive Era makes clear, prioritizing expertise in governance of public institutions raises questions concerning democratic legitimacy that need to be parsed carefully (Hofstadter 1955). Even expert networks can be more or less open; the Pittsburgh smart city experience teaches that participating in smart city governance may require little more than volunteering some time, as in the community-based odor detection application called Smell Pittsburgh.

Pittsburgh's expertise network is fluid enough that it is far from limited only to graduates of CMU and Pitt. But mid-level staff professionals advancing smart city initiatives in the City of Pittsburgh during the Peduto administration possess, at the least, master's degrees.

In sum, if one of the goals of knowledge commons governance and related research is to understand how to advance overlapping goals with respect to improving the quality of knowledge resources and knowledge governance, then researchers need to carefully unpack questions of hierarchy and influence, communications patterns, legitimacy, authority, reliability and trust, accountability, and transparency. Those are all values associated with relevant expertise as such and in collective settings (Abbott 2001). And researchers need to pursue those questions while carefully separating them from questions of elite status or political, economic, or cultural power (Latour 1988). In what respects are knowledge-sharing strategies imposed on the broad Pittsburgh community? In what respects is the broader community even aware of the existence of those strategies, let alone given an opportunity to voice their participation in governance strategies, by voting or otherwise contesting them? In Pittsburgh, the questions of power and elite status, and presumptive exclusion of the broad community from decisions about community welfare, were more clearly in evidence earlier in Pittsburgh's twentieth-century experience. In the twenty-first century, the cultural authority of entitled elites has receded somewhat, but it finds echoes in the persistent influence of Pittsburgh's largest philanthropic organizations and in the thick partnerships between Pittsburgh's public sector and its research universities.

Hidden Intelligences

What's missing in this account? Even a broad focus on the smart city risks missing important attributes of knowledge governance in the urban experience. In

Pittsburgh, that means medicine. Undoubtedly the largest and most socially impactful contemporary data-sharing practice in Pittsburgh is not part of Pittsburgh's smart city inventory. It is a data-sharing agreement begun in 2016 between UPMC Health Systems, the region's largest clinical health care provider; the University of Pittsburgh, which houses a health sciences research program across six separate professional schools that is funded with close to $1 billion annually in US federal research sponsorship; and CMU, one of the world's leading research universities with respect to computer science. This Pittsburgh Health Data Alliance, which now also partners with Amazon Web Services (AWS), feeds clinical care data from UPMC to the Alliance's combination of medical, biomedical informatics, and computer science research communities. State-of-the-art machine-learning power is directed to developing precision medicine therapies based on nearly thirty years' worth of clinical data. The relatively low population movement historically associated with Western Pennsylvania means that UPMC stores richer longitudinal data based on patient care than most of its peers in other US regions.

Within the medical research community, this is a highly unusual program, with extraordinary practical potential payoffs and also extraordinary ethical complexity. Outside of the medical research community, however, it is, to an even greater degree than the AFST, out of view of the broader Pittsburgh community. The only community health experience in Pittsburgh of comparably broad impact was the development and testing of the polio vaccine during the early 1950s. Thousands of Pittsburgh children accepted shots in their arms, a collaborative, public undertaking of a distinctly material and immaterial sort that Pittsburgh is proud to share and celebrate as a community triumph (Greidanus 2010). The Pittsburgh Health Data Alliance operates almost entirely and solely as a function of the community of medical experts.

CONCLUSION: THE FUTURE OF THE SMART POSTINDUSTRIAL CITY AND THE USES OF KNOWLEDGE COMMONS

The smart city presents different stories about whether cities and their residents should care about being "smart." This chapter has addressed one specific US city, Pittsburgh, Pennsylvania, as a case study of how those different stories are represented on the ground. The chapter takes the Governing Knowledge Commons research framework as its essential organizing device. The GKC framework draws out the shareable and shared character of the immaterial resources – the multiplicity of knowledge, information, and data resources that lie at the heart of what it might mean for a city to be "smart" – and connects them to the contingent immaterial and material resources that are often more commonly associated with the city – geography, culture, and history.

The Pittsburgh case study teaches that smart city data is only one immaterial feature governed as a complex, shared resource. Governance techniques and expertise themselves also constitute important immaterial shared knowledge features of the

smart city. Pittsburgh further teaches that the smart city isn't necessarily the new, bright, futuristic phenomenon described by some promoters. The smart city may be inextricably linked to attitudes and cultural patterns of long standing. In governance terms, Pittsburgh as a twenty-first-century smart city in formation bears a strong resemblance to Pittsburgh as a twentieth-century steel-making powerhouse. Whether Pittsburgh was "smart" 100 years ago is no more significant, however, than whether Pittsburgh is "smart" today. The GKC framework exposes both historical and contemporary context for urban governance.

The idea of the city has been linked for centuries with three key overarching metaphors. Two of these – the city-as-machine and the city-as-living-organism – are often used in different ways as baselines for evaluating smart cities. Both of these have long and respected histories. The history of machine-based, techno-utopian dreams of administrative and social efficiency runs from the present day (Goldsmith and Crawford 2014), through the Progressive Era (Caro 1974), and to antiquity (Scott 2017). A counter-narrative, featuring cities as naturalistic organisms or ecologies, runs essentially as long (Frug 1999; Mattern 2021; O'Mara 2007). There is also a notable history of efforts to meld the two metaphors in analysis and practice, via what one historian called Buckminster Fuller's "cybernetic pastoral" (Massey 2006).

Often overlooked in that debate is a third grand metaphor with ancient roots: the city as spiritual – and therefore immaterial – ideal (Mumford 1961; Rykwert 1976). This perspective draws out subtle but critical contrasts with respect to the duel between the first two metaphors. Both of those are essentially materialist metaphors; in different ways they are advanced by both the rationalist planners and also by their evolution and ecology-minded critics (Jacobs 1961; Sjoberg 1965).

The immaterial metaphor is relevant and important to smart city research in that researchers should be attentive to the uses of immaterial ideals as goals or pathways for the modern city itself. Should the smart city be framed as an immaterial "knowledge commons," which is, in a way, a kind of spiritual ideal? This chapter has assumed the relevance of that question. Further research should explore that topic in greater detail.

That means that the smart city may not be simply another step on the evolutionary pathways of the city as such. The smart city may be a qualitatively different phenomenon altogether, a dematerialized "space" that residents choose – or exit – for reasons having to do with their roles in knowledge, information, and data governance rather than simply another site in centuries-old debates about cities and political economy.

Dematerialization of community engagement and identity in the smart city may mark the end of what has historically made the city a critical site of economic activity. People will still live in agglomerated settings, but economic activity related to those agglomerations may cease to be a meaningful driver of the agglomeration. People won't need to live where they work, or vice versa. They might live where they choose to live, including in cities. Today, we connect as much via representations in

data and on screens as we do via embodied interactions. It's entirely possible to live in a place yet participate little in traditional local communal or economic life and participate a lot (or not) in knowledge governance.

If the smart city means that what cities are for and how cities are constructed is changing fundamentally, should investigations of urbanism change fundamentally too?

That question is salient because of the Covid-19 pandemic that began in 2020, but it's not new. Rae, writing in 2005, described the end of urbanism, as market dynamics and exit by city residents started to change the basic character of a city as a place where people collaborate to solve their problems (Rae 2005). Is Pittsburgh headed in that direction, becoming less of a place in itself that relies on a century's worth of inherited industrial success, and more a mode of place-centered affinity that people choose based on how they experience life on the screen and in the database? The GKC framework should be useful as a device not only for understanding how knowledge commons in the smart city begin and carry on but also for understanding how they end.

DISCLOSURE

From 2017 to 2019, I was the Academic Director of the University of Pittsburgh Institute for Cyber Law, Policy, and Security, known as Pitt Cyber. Pitt Cyber receives funding from various corporate and philanthropic supports in Pittsburgh, including the Heinz Endowments. I have no connection with research or public policy interventions supported by Pitt Cyber that are directed to City of Pittsburgh or Allegheny County operations, or to any programs mentioned in this chapter.

I was previously Faculty Director of the Innovation Practice Institute at the University of Pittsburgh School of Law, which was funded in part by the Heinz Endowments.

I am a member of the board of directors of the Partnership to Advance Responsible Technology (PART), a nonprofit organization based in Pittsburgh that receives funding from the Richard King Mellon Foundation.

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