How National Governments Can Help Smart Cities Succeed

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Cities around the world are undergoing two important transformations. First, they are growing. For the first time in history, a majority of the world's population lives in urban areas.[1] Second, they are beginning to evolve into "smart cities"—cities capable of collecting and analyzing vast quantities of data to automate processes, improve service quality, provide market signal feedback to users, and to make better decisions. While city governments can and should manage much of this transformation, national governments have an important role to play in accelerating and coordinating the development of smart cities. Indeed, the long-term success of smart cities in any particular nation will likely depend on whether the national government supports their development.

Cities cannot complete the evolution into smart cities on their own.

Cities of all sizes are beginning to use an array of technologies, including low-cost sensors, wireless communication systems, data-actuated devices, and advanced data analytics to operate more intelligently. Cities can use these technologies to address many key challenges, such as traffic congestion, crime, and pollution, as well as to improve the quality and reduce the costs of a vast array of government services. The emergence of smart cities is a marked departure from the past when most urban systems—roads, transit, waste-removal systems, the electric grid, and buildings—had few, if any, built-in capabilities to measure and act on their performance, particularly in real time. With the development of new technologies to collect, analyze, act on, and share municipal data, urban infrastructure and services no longer need to be static and unresponsive, but can instead adapt to changing needs.

However, cities cannot complete the evolution into smart cities on their own. There are five key challenges limiting smart city development that

even the most capable of cities will likely not be able to overcome on their own. These are:

- Too Much Risk: Cities have little incentive to be early adopters of new smart city technology when that means they bear all of the risk of failure. Instead they have an incentive to wait until others have worked out the challenges. Similarly, while public research and development (R&D) will be critical to the success of smart cities, such as improving cyber security and establishing demonstration projects, a city cannot be expected to take on the costs of R&D in exchange for only a small share of the total benefits it will generate.
- Lack of Focus on Smart Infrastructure: Many national governments' infrastructure funding focuses almost exclusively on enabling cities to build and maintain traditional "concrete and steel" projects. This leaves little opportunity for more capable and innovative cities, which rely on national government funding, to pursue smart infrastructure built around "concrete and chips."
- The Need for Interconnected Smart Cities: If cities can share and compare data with one another, governments can reduce costs, as well as analyze larger pools of data, enabling more accurate and actionable insights. However, cities are not equipped to develop interoperable systems and share data across their jurisdictional boundaries.
- Lagging Communities of Practice: Building and operating smart cities will require a significant change from the normal way of managing cities, and local leaders need to be able to easily share their successes and failures and learn from their peers. If every city experimenting with smart city technology would share what they learn, every other city would benefit. But without an initial critical mass of cities capable of developing and sharing these insights, overall learning and action will remain limited.
- The Need to Ensure Equity: Smart city technologies have great potential to help address the needs of underserved communities, however these technologies can also exacerbate inequalities if applied or adopted unevenly, which simultaneously limits the efficacy of these technologies. Municipal governments can enact policies to help ensure the equitable distribution and application of smart city technologies, but historically efforts to promote equity have been supplemented by national government efforts, suggesting municipal actions alone would be insufficient.

Fortunately, national governments can provide solutions to all these challenges. Cities will rightly make the majority of investments and decisions related to their evolution into smart cities. However national governments have a key role to fill in addressing the problems cities

cannot resolve on their own, particularly in the early stages. Importantly, large portions of the role of national governments will be temporary. While national governments should always be involved in supporting innovation, their main goal with smart cities is to enact policies that set in motion significant shifts in how cities operate that will allow this evolution to be self-sustaining. Thus, some of the roles for national governments in smart cities will be temporary—for example, once robust communities of practice arise for smart cities, national governments do not need to heavily encourage their development—while others, such as promoting equity, may be ongoing. National government solutions include:

- Supporting shared projects in at least four areas: 1) R&D on key technical challenges, such as cyber security; 2) research and demonstration projects that develop and test particular new smart city applications; 3) shared applications and tools that make cities better equipped to work with smart technology and data; and 4) demonstration projects to establish a few comprehensive smart cities to test system-wide applications.
- Allocating a share of infrastructure investments to specifically target smart infrastructure, such as intelligent transportation systems and smart grid systems.
- Developing policies and common standards for smart city technologies that encourage interoperability and data sharing to increase the effectiveness of smart city applications and increase the value proposition for smart technologies.
- Fostering collaboration and coordination in the smart city ecosystem to facilitate inter-city learning and reduce knowledge-sharing barriers.
- Ensuring that efforts to support smart cities, such as through pilot programs, infrastructure investment, or support for public-private partnerships, address the needs of underserved communities.

THE BENEFITS OF SMART CITIES

Smart cities are those that use sensors, data, and analytics to tackle important issues such as how to better manage sanitation systems, improve transportation networks, and deliver government services more efficiently.[2] Most smart city applications are built around the Internet of Things–objects embedded with sensors and wireless connectivity to enable them to send and receive data that can be analyzed and acted upon. Other enabling smart city technologies include wired and wireless broadband networks; analytics tools to process data coming from sensor networks; and autonomous systems.

There are many potential applications of smart city technologies, and many more will arise as the technologies mature and achieve widespread adoption. Areas of application include transportation systems, infrastructure monitoring, natural disaster detection, utility system management, environmental monitoring, urban planning, public safety, municipal service delivery, public lighting, and many others.

It is difficult to estimate the potential economic and social benefits smart cities will generate. Smart city applications are only just emerging and there is no telling just how transformative they will be once they mature. However, the success stories of early adopters are promising. For example, Santander, Spain was able to cut energy costs by up to 25 percent by installing smart street lights that automatically dim when nobody is nearby.[3] In Seoul, South Korea, smart trash cans that city workers can monitor in real time reduced waste collection costs by 83 percent.[4] And in Israel, the cities of Jerusalem and Netanya are using sensor networks to rapidly identify when and where leaks occur in their water infrastructure and will use the data from this system to perform preventative maintenance to prevent costly pipe bursts.[5] Though these examples just scratch the surface of the benefits of smart cities, it is reasonable to assume that in a smart city, most city functions could benefit from data that gives them the potential to be more efficient, responsive, and effective.

SMART CITY DEVELOPMENTS AROUND THE WORLD

Many countries have recognized the potential value of smart cities and have taken steps to accelerate their development. Though several countries have launched high-profile initiatives to develop smart cities, only a select few countries have made significant progress. The following lists some high-profile developments.

INDIA

India launched an urban modernization initiative called the “Smart Cities Mission” on June 25, 2015 with the ambitious goal of creating 100 smart cities over a five-year period.[6] The funding is also ambitious, with the national government allocating 480 billion rupees (US $7.5 billion) to the initiative and requiring matching funding from participating cities.[7] While some participating cities’ proposals include a focus on the use of information technology, a large portion of the Smart Cities Mission is devoted to basic modernization and quality of life improvements, such as ensuring cities have reliable electricity, water supply, and waste management, and promoting walkability.[8] In fact, the Ministry of Housing and Urban Affairs, which oversees the Smart Cities Mission, does not substantially emphasize the use of data and smart technology in its

definition of smart cities. As such, India's Smart Cities Mission is not truly about smart cities in the commonly understood sense of the term.

SINGAPORE

While Singapore is a nation, it is also a city-state, and as such has advantages in deploying smart city technology. In November 2014, Singapore launched the Smart Nation Initiative, investing $1.6 billion in the development and deployment of a national system of sensor networks and supporting communications infrastructure.[9] Singapore invested another $2.8 billion in the Smart Nation Initiative in 2016, pledging to extend Wi-Fi coverage to every public school, optimize and increase the government's data storage capacity, and provide all public servants with laptops over the next three to five years.[10] Singapore's use of smart city technology and analytics is fairly pervasive, monitoring everything from green-energy initiatives in affordable housing communities to the development of a city-wide system of self-driving buses.[11] Since 2015, Singapore's Elderly Monitoring System (EMS) has installed movement-sensors in seniors' homes to monitor movement and can alert family members and caregivers via text in the event of an abnormally long period of inactivity.[12] One of Singapore's most ambitious smart city ventures is Virtual Singapore, a digital 3D model of the island that can serve as a dashboard for municipal data sources, including sensor networks, census information, and geographic information systems.[13] Virtual Singapore will enable a wide variety of useful urban planning and management applications, such as interactive simulations demonstrating how new buildings would affect airflow in cities or how altering bus routes would affect commute times across Singapore.

SOUTH KOREA

South Korea is the home of the world's first purposefully built smart city, Songdo City, which was made possible thanks to the Korean government's efforts to make the land suitable for development by filling in marshland with landfill and the creation of a special economic zone, with tax breaks for businesses and limited regulations, to incentivize businesses to move there.[14] The government developed the public infrastructure while private developers funded the bulk of the building of Songdo, particularly the Songdo International Business District, a six square kilometer public-private real estate development that makes extensive use of connected technologies in residential and commercial buildings. The Internet of Things covers the city, with sensors built into the roads, buildings, and public transportation.[15] Songdo's developers have also partnered with Cisco to develop a system called U-Life that helps residents and businesses use a variety of smart city services, such as smart wallets to pay for public transit and remote-controlled building management.[16]

UNITED KINGDOM

In 2012, Innovate UK, the innovation agency of the United Kingdom, allocated £34.5 million (US $55.89 million) in funding to allow 30 cities across the United Kingdom, including Glasgow, Bristol, and London, to research smart city policies and develop proposals about how smart city technology could benefit their cities.[17] In 2013, Innovate UK launched the Future Cities Catapult, an urban innovation center that works with economists, engineers, businesses, and city officials to finance and establish smart city applications.[18] The Future Cities Catapult also develops IoTUK, a series of initiatives designed to increase adoption of the Internet of Things, and in 2015, with £10 million ($16.2 million) in funding from Innovate UK, helped the city of Manchester develop a smart city demonstrator pilot called CityVerve.[19]

UNITED STATES

The Obama administration launched its Smart Cities Initiative in September 2015, committing $160 million in funding ($105 million in new spending as well as reprogrammed funds) to a wide array of Internet of Things applications, including, but not limited to, smart cities.[20] The Smart Cities Initiative includes support for a range of programs including the National Institute of Standards and Technology's Global City Teams Challenge, which encourages the development of smart city applications, Internet-connected vehicle pilots, and the establishment of Internet of Things research test beds.[21] The federal government's Networking and Information Technology Research and Development Program also released its Smart Cities and Connected Communities Framework—a guide to coordinate federal agency investment and collaboration for smart city technology.[22] And in December 2015, the Department of Transportation launched the Smart City Challenge, which awarded $40 million in March 2016 to Columbus, Ohio—a mid-sized city—to implement connected technologies to reduce congestion, improve transportation safety, protect the environment, and support economic growth.[23] However the 15 projects the Smart City Challenge is funding in Columbus have a relatively narrow focus on transportation, and the city must still integrate many additional systems to build a comprehensive smart city.[24]

PROBLEMS LIMITING SMART CITY DEVELOPMENT AND THE ROLE FOR NATIONAL GOVERNMENTS

Local governments will make most of the decisions related to the deployment of smart cities, as they are in the best position to understand and act on the unique opportunities and challenges specific to their cities. However, cities face an array of challenges limiting smart city development that they are not well-equipped to address, while national governments are. If a national government fails to fill this role, the transformation to smart cities in that country will be slowed.

TOO MUCH RISK

The problem: Given the fact that smart cities are new, many municipal governments will perceive investments in smart city initiatives as risky, making it harder for them to justify this spending regardless of the potential return on investment these technologies can offer.[25] For example, Geoff Snelson, the leader of a smart city initiative in Milton Keynes in the United Kingdom called MK:Smart, calls smart city technologies "classic Valley-of-Death stuff—there are great ideas but, until you deploy them at scale, you do not know enough about it. All the big vendors are going round asking why people aren't buying their products, and we are saying: 'when can it be demonstrated [at scale]?'"[26] Cities have little incentive to be an early adopter of new smart city technology, especially at scale, and bear all of the risk when they could instead wait until others have already worked out its challenges.

Similarly, cities have little incentive to invest in research, development and demonstration (RD&D) for particular technologies that support smart cities because they would shoulder all the costs for only a small portion of the benefits. Though the whole smart city ecosystem benefits from public RD&D, it is not reasonable to expect any one city to foot the bill just so every other city can reap the benefits.

The solution: National governments should support shared projects in at least four areas: 1) R&D on key technical challenges, such as cyber security; 2) research and demonstration projects that develop and test particular new smart city applications; 3) shared applications and tools that make cities better equipped to work with smart technology and data; and 4) demonstration projects to establish a few comprehensive smart cities to test system-wide applications.

National governments should support R&D for smart city technologies because cities would not fully capture the benefits of investing in R&D themselves, leading to underinvestment. Public R&D is important because it can create advances in the underlying technologies of smart cities that all smart city stakeholders can benefit from, including areas like cybersecurity for smart infrastructure. For example, in February 2017, the U.S. government's Networking and Information Technology Research and Development (NITRD) Program published a strategic plan to support smart cities by accelerating R&D in areas such as software-defined networking, automation, and cybersecurity, noting that by conducting this fundamental research, the federal government could develop a "foundation for subsequent applied research as well as activities that support transition of research innovations into city/community settings, including at-scale testing."[27] National government R&D investment in smart city technologies would have the added benefit of spurring additional private-sector R&D spending in this field.[28]

National government R&D investment should support partnerships between industry, academia, and government. One model is the U.S. National Science Foundation's National Network of Big Data Regional Innovation Hubs program to create regional consortia of industry, academic, nonprofit, and local government partners that carry out research related to big data applications.[29] Similarly, the United States' Manufacturing USA initiative, launched in 2014, coordinates federal funding and programs to support a network of industry-led public-private partnerships researching and developing advanced manufacturing technologies to spur private-sector adoption of these technologies and help companies scale up.[30]Countries should establish similar programs to develop strong linkages between industry, academic and government researchers, and governments, to accelerate innovation in smart city technologies.

National governments should also develop pilot projects and test bed programs that enable a few cities to "go first" and establish proof of concept designs for a wide array of smart city applications, which, assuming successful, would encourage other cities to adopt these projects. Funding for these research and demonstration projects should come with stipulations that ensure recipient cities use these funds on high impact projects that can be duplicated elsewhere. For example, the United States' Smart City Challenge required that participating cities develop plans to use smart technologies to address major transportation-related challenges, including public safety, energy efficiency, and access to economic opportunity.[31] The European Union's Horizon 2020 Lighthouse Projects require participating cities to address similar high-impact issues with smart technologies, but also focus on developing smart city applications that would be easy for other cities to replicate, as well as emphasize the use of near-to-market technologies to accelerate their development.[32] Replicability of smart city projects will be particularly important for smaller and rural communities that lack the funding, human capital, and infrastructure to take risks and experiment with smart technologies themselves. Countries with large rural populations should consider also launching research and demonstration programs tailored to the needs of these communities. For example, a rural community would benefit far more from expanded broadband coverage than it would from smart public transit systems or smart public waste management.

National government funding that goes to developing smart city tools in-house should require that these tools to be open source so that this investment can benefit as many cities as possible. While the private sector can and will develop many tools for smart cities, governments should develop shared, freely available tools when the market fails to provide them, such as for applications with high public value but which the private

sector may not prioritize. For example, in the United States, the Census Bureau, Department of Commerce, Department of Housing and Urban Development, and other federal agencies partnered to develop CitySDK (software development kit), a digital toolkit designed to make it easier for developers to build civic applications with open data.[33] Additionally, the European Commission and Japan have partnered on several initiatives to develop smart city tools designed to accelerate the deployment of smart technologies and help cities take better advantage of data.[34] The ClouT ("cloud of things") project, for example, develops cloud infrastructure, services, and tools for smart city applications in partnership with Japanese and European cities and companies.[35] The European Commission and Japan also launched the FESTIVAL project in 2014 to develop testbed platforms for smart city technologies, particularly ones based on the Internet of Things, to facilitate their development.[36] Similarly, national governments can also provide a platform to make it easier for cities to share tools they've developed with each other. Relatedly, national government funding for smart city initiatives should require that cities make the data generated from these initiatives publicly available as open data. Sharing data, just like sharing software tools, can substantially increase the value of smart city applications.

Finally, national governments should fund smart city initiatives focusing on developing a few comprehensive smart cities that incorporate smart technologies and data into virtually all aspects of their communities, including municipal services and agencies. To date, most smart city pilot programs have funded a few discrete projects in a handful of cities. This is useful, but cities also need to study how cities can fully integrate smart city technology across every agency. To do this, national governments should identify a few medium-size cities willing to pilot a large number of different projects operating simultaneously. The goal of this effort would be to learn how to integrate multiple complex smart city technologies so as to maximize the benefits and synergies. Any city can invest in one-off smart projects such as smart traffic signals, but by developing a smart city in such a piecemeal manner, cities risk developing less valuable, fragmented systems as individual agencies will deploy systems that meet their own specifications and needs, with little consideration for how their technology and data can integrate with other smart city systems to deliver actionable insights.[37] Pilots of comprehensive smart cities will generate insights that national governments can use to create roadmaps for smart city development elsewhere. Most cities typically will become smart one project at a time, rather than comprehensively rebuild themselves from the ground up; these roadmaps can help them plan out individual projects bearing in mind how it will fit in with future projects.

Singapore has established the most successful smart city development program, however as a city-state it is uniquely suited to implement nation-

wide, comprehensive smart city initiatives. But even this program has only scratched the surface of all possible applications. Other countries have made significant investments in smart city pilots, however many have shortcomings or inherent limitations that reduce their return on investment. For example, though many features of Songdo are impressive and building a smart city from the ground up offers some advantages over retrofitting an existing city, the South Korean government failed to ensure that Songdo would actually be a successful city, in terms of being a desirable place for people to live and work, regardless of the technology deployed. Originally planned for completion by 2014, the city is now scheduled to be completed by 2020, and it has attracted just 70,000 daily commuters, compared to the 300,000 originally expected.[38] Additionally, Songdo has struggled to attract domestic businesses, as the incentives of the South Korean government's special economic zone benefit only international firms.[39] The United States' Smart City Challenge was a step in the right direction for the country, which had previously significantly lagged behind the rest of the world in smart city investment; however the limited focus of the projects will come nowhere near to making Columbus a fully smart city.[40]

Any national RD&D projects should place a top priority on projects that will improve efficiency and save money, either for residents, businesses, or governments. As these programs develop, they will help establish best practices for smart city development as well as mature the smart city industry, further reducing risk.

LACK OF FOCUS ON SMART INFRASTRUCTURE

The problem: Many cities are slow to build hybrid physical-digital infrastructure—systems that societies use to transport goods, people, or information, augmented by information technology, also known as smart infrastructure—because they are simply trying to keep up with the urgent needs to deploy more traditional physical infrastructure projects.[41] In these cities, the backlog of construction and maintenance tasks for their physical infrastructure leaves them little time or resources to focus on hybrid infrastructure. In short, cities have little capacity to take on "concrete-and-chips" projects when they are so busy with "concrete-and-steel" projects. National government infrastructure funding usually exacerbates this problem by focusing most infrastructure funding on physical infrastructure instead of hybrid infrastructure.

The solution: Many national governments have made commitments to expand funding for physical infrastructure.[42] They should ensure that a share of infrastructure investments is specifically targeted to smart infrastructure, such as intelligent transportation systems and smart grid systems, to considerably accelerate the deployment of smart technologies.[43] While subnational governments also spend a large amount

of money on infrastructure, national government spending is likely better suited to the task of building smart infrastructure or retrofitting existing "dumb" infrastructure with smart technologies; this is because transportation networks, power grids, and other infrastructure systems often span multiple jurisdictions. Additionally, national governments are likely better equipped to handle infrastructure development, while cities would benefit more from maintaining infrastructure.[44] For example, two-thirds of the $100 billion the U.S. federal government spent on infrastructure in 2014 went to rehabilitating structures and equipment, or building new infrastructure entirely, whereas state and local governments devote the bulk of their funds to infrastructure operations and maintenance.[45] Governments should initially target smart infrastructure funding to cities that have proven to be capable of taking on more ambitious technology-driven infrastructure projects, which can help develop successful deployment models that would make it easier for cities still struggling with concrete-and-steel projects to deploy smart infrastructure. There is a compelling cost-benefit justification for this approach as well, as taxpayers get a greater return on national funding spent on more beneficial smart infrastructure, such as intelligent transportation systems, than on infrastructure that does not take advantage of data-driven technologies.[46]

THE NEED FOR INTERCONNECTED SMART CITIES

The problem: A smart city will benefit from analyzing its own data; however smart cities would get far greater value from analyzing larger pools of data generated by all other smart cities. Much as sharing patient data between health-care researchers can lead to the development of new treatments and improvements in patient care, if cities share data, governments can analyze larger pools of data, enabling more accurate and actionable insights. However, cities are not well equipped to develop interoperable systems that span local and even national boundaries. Additionally, while cities benefit from analyzing other cities' data, an individual city itself has little incentive to share data. Moreover, cities may enact policies that limit data collection and sharing, perhaps due to fears about privacy or cybersecurity risks, counterproductively prioritizing their own immediate interests and not the value that could be created if all cities shared data in a common pool.

This is unfortunate, as sharing data nationally and internationally has considerable benefits. With larger pools of granular data, national governments can much more effectively analyze the impact different policies have on their cities and communities. Additionally, by enabling smart cities to share data internationally, cities with similar challenges can more effectively learn from one another.[47] For example, New York likely has more in common with London and Tokyo than with many cities in the

United States; by analyzing each other's data, such large cities can generate insights that would they would not be able to if they were limited to only analyzing data from within their own national borders.

The solution: Develop common policies and standards for smart city technologies that encourage interoperability and data sharing to increase the effectiveness of smart city applications and increase the value proposition for smart technologies.

While the private sector should lead the development of technical standards in most cases, national governments have an important role to play in standards coordination for smart city applications.[48] For example, the UK government's Technology Strategy Board, now called Innovate UK, sponsored an industry working group in 2014 to develop an open standard for the Internet of Things to facilitate data sharing between new devices.[49] Then in 2015, the group launched an initiative called HyperCatCity to encourage smart city technology firms working with the public sector to adopt the HyperCat standard.[50] National governments should promote the adoption of common, nonproprietary technical standards for smart city technologies and work with the private sector to develop common standards where they do not exist. Ubiquitous adoption of common open standards could allow cities to adopt a "plug and play" approach to smart city development–cities can buy the technology that best meets their needs without worrying that it might not be able to integrate with its other systems, and cities can adopt smart technologies incrementally without the risk that the technology they have today might not interoperate with a system they want to use ten years down the line. Without these steps, cities will struggle to develop interoperable networks of smart city technologies and will be unable to take full advantage of data they generate.

Rules governing data collection and sharing can substantially influence how effectively a city can leverage smart city technology. And even without explicit restrictions on data collection and use, privacy fears and a lack of understanding about the technology can slow smart city development. For example, Chicago's Array of Things project to deploy sensor hubs throughout the city to track things like air quality and pedestrian traffic has been hampered by misguided fears that this benign data collection would invade people's privacy.[51] The project has lagged considerably due in part to counterproductive efforts, such as the Electronic Frontier Foundation labeling the project "research hubris," despite the fact that no personally identifiable information was ever at risk.[52] Some cities will be apprehensive about data collection and sharing no matter how benign. If policymakers were to enact counterproductive restrictions for smart city technology, this would reduce the value proposition of these technologies for many cities and slow smart city development. More importantly, this would harm the

smart city ecosystem as a whole. A large portion of smart city technologies will be built around the Internet of Things and data analytics and thus will become more valuable at scale because of network effects. If governments create regulatory barriers to these widespread deployments, the applications and services built around data will be less effective—smart systems that police departments could use to reduce crime, such as networks of gunshot detection sensors and predictive analytics, would be substantially less effective if they can only share data with select cities, limiting the amount police could learn.[53] In such cases, national governments should use their leverage to require system-wide data sharing for analytics structured to, when appropriate, de-identify any personally identifiable data. Importantly, national governments should also stress that only a small portion of smart city data would be personally identifiable information to begin with and work to dispel misinformed privacy fears as they arise.

National governments should establish model policies that maximize the use and reuse of smart city data. Rather than having to develop their own data use policies, cities could instead simply adopt the national model policy. This would remove barriers to deployment for smart city technology on the local level, as well as protect against the development of complicated webs of differing legal frameworks from city to city, which can drive up regulatory costs and slow the growth of the technology.

LAGGING COMMUNITIES OF PRACTICE

The problem: The emergence of new technologies can transform cities. Cities have faced the challenge of integrating many new technologies, such as electricity, indoor plumbing, sewage systems, and cars. While cities eventually benefited from integrating these technologies, the reluctance of many cities to embrace them, and to adapt their operations to change and innovation, delayed progress.

Today, the emergence of smart city technologies poses similar challenges and provides similar opportunities for cities. Just as the development of prior technologies required significant changes in how governments managed cities, smart city technologies will require municipal leaders to adapt and learn how to use the new tools at their disposal. As such, smart city management and data-driven governance represent significant departures from the normal way of doing things. Indeed, developing and managing smart cities will require new skillsets. Yet in most nations there are few mechanisms for city officials to connect with and learn from each other when it comes to smart cities transformation.

Smart city progress will accelerate if cities can easily share successes and failures and learn from their peers. If every city that was experimenting with smart city technology and data-driven governance was also sharing what

they learn, every other city would benefit. However, without a system by which cities can develop and share these insights, progress will be stunted as cities attempt to progress by slow trial-and-error methods while needlessly making the same mistakes as their peers.

The solution: National governments should foster collaboration and coordination in the smart city ecosystem to facilitate inter-city learning and reduce knowledge-sharing barriers. As smart cities are still emerging, there are not yet widely understood best practices about how to deploy smart technology and manage smart city services. As the public and private sectors experiment with smart city technologies and develop these best practices, knowledge gaps that exist between cities greatly slow smart city deployments. Thus, collaboration in the smart city ecosystem will be instrumental to their success and timely development. While cities have some capacity to work with each other on their own, they largely do not work to solve the collective action problem of creating learning communities. As such, national governments are better positioned to foster this kind of collaborative learning.

To develop communities of practice and thereby enable cities to learn from each other, national governments should help develop shared methods for understanding and comparing smart city performance. In an ideal smart city, a system that analyzes a city's sensor data, administrative data, and data from other sources would provide users of the data with an easy-to-understand metric reflecting the performance of a particular policy, infrastructure project, or city program. For example, with smart city technologies policymakers will be able to easily assess the impact a new bus route has on pedestrian traffic, employment in nearby areas, and the air quality of a particular neighborhood. Smart city performance metrics would allow cities to identify the best smart city solutions as well as help policymakers assess the effectiveness of different practices.[54]

Several standards bodies have developed a variety of performance standards for this purpose.[55] Most notably, the International Organization for Standardization (ISO) has developed a standard (ISO 37120:2014) designed to measure how well a city performs in 100 indicators across 17 key areas, including education, fire and energy response, transportation, and water and sanitation.[56] As more cities deploy sensor networks and begin collecting more data on their operations, widespread adoption of common performance standards will become all the more important to ensure city managers are taking full advantage of smart city technologies. This data-driven approach to city governance may be difficult for many cities to adopt due to a lack of experience with data-driven decision-making. Furthermore, as much of the value of these performance standards come from their capability to enable comparisons between cities, national governments have an incentive to encourage their

widespread adoption. Thus, national governments should implement incentive programs that reward cities for both adopting these common standards, as well as for how effectively they use smart city technologies to improve their performance, and how well they share data and nonproprietary software tools with each other.

Just as importantly as developing the systems for effective knowledge sharing, national governments should use a variety of methods to build robust communities of practice for smart cities that integrate industry, government, and academia. Some national governments have already recognized the benefits of this approach. In the United States, the National Institute for Standards and Technology oversees the Global City Teams Challenge, an initiative to foster collaboration among government agencies, universities, non-profits, and companies on smart city projects and "to establish and demonstrate replicable, scalable, and sustainable models for incubation and deployment of interoperable, standard-based solutions using advanced technologies such as [the Internet of Things] and [cyber-physical systems], and demonstrate their measurable benefits in communities and cities."[57] The United Kingdom's Future Cities Catapult has a similar mission, focusing on bringing together city leaders, businesses, and universities to advance innovative solutions to urban challenges.[58]

National governments can also routinely convene roundtables for city leaders, industry representatives, and researchers to help shape policy and develop relationships. As part of Australia's 2016 Smart Cities Plan, which aims to maximize the potential benefits of smart cities, the government created the Cities Reference Group consisting of public and private-sector leaders to advise on policies to support smart cities.59 In some cases, national governments can leverage existing industry and academic partnerships to build communities of practice by providing them funding or giving them platforms to reach a broader audience. For example, the Chicago-based UI Labs, a research and commercialization partnership between local industry and universities, runs a program called City Digital to serve as a testbed to deploy smart city technologies in Chicago focusing on physical infrastructure, water and sanitation, energy management, and mobility.[60]

THE NEED TO ENSURE EQUITY

The problem: There is a risk that cities may not deploy smart city technologies in ways that serve all communities effectively. If only certain populations can routinely access and enjoy the benefits of smart city technologies and the data they generate, other populations are left at a relative disadvantage. This concept is known as the "data divide" or "data poverty" where the lack of collection or use of data about an individual or

community produces or exacerbates social or economic inequalities.[61] This a problem of efficacy just as it is about equity, because smart city technologies and data-driven applications are less effective if they have to rely on incomplete and non-representative data.[62] For example, smart city technology that police departments use to reduce crime would be substantially less effective if they could only analyze data from certain neighborhoods.[63] While municipal governments can enact policies to help ensure the equitable distribution and application of smart city technologies, protecting underserved communities has historically also been the role of national governments, and they should continue to exercise it in smart city development.

The solution: National governments should ensure that their efforts to support smart cities, such as through pilot programs, infrastructure investment, or support for public-private partnerships, address the needs of underserved communities.

In many cases, this will simply mean educating cities about how to ensure equitable distribution of smart technologies throughout a city or targeting deployments of these technologies to the most in-need areas. For example, national government housing agencies such as the U.S. Department of Housing and Urban Development or the U.K. Homes and Communities Agency should ensure that housing development programs integrate smart technologies. Similarly, national government funding for accessibility programs should emphasize the use of smart technologies to increase accessibility for people with disabilities. For example, by installing sensors in accessible parking spaces and making parking spot availability data publicly available, cities could enable city residents with disabilities to easily identify the nearest accessible parking spot from their smartphones.[64] With this data, cities could also better monitor the demand for accessible parking and create additional spaces if necessary. National governments should also engage with municipal leaders in underserved communities and help train them to use smart city technologies.[65] Additionally, national governments should collect statistical data about smart city deployment to evaluate how cities are prioritizing the deployment of different smart technologies, which could reveal potential equity concerns.

However, cities are complex systems and in some cases simply ensuring equitable deployment of technology will not be enough to protect against creating inequality. For example, upgrading transportation infrastructure and public transit with intelligent transportation systems can increase the accessibility of jobs, education, and health care for residents. But if existing transportation infrastructure does not serve all communities of a city equitably, simply upgrading this existing infrastructure will do little to help those communities already at a disadvantage. Furthermore, intelligent

transportations systems could potentially change the traffic patterns in and around a smart city, benefitting certain areas and disadvantaging others in unforeseen ways. City leaders will have to implement new management processes to properly leverage smart city technology, but many may not have the skills to do so. To address this, national governments can create educational materials and online training to give local leaders the skillsets they need to make the best and most equitable use of smart city technology.

Fortunately, as more communities adopt smart city technology, governments will have access to more data than ever before about how cities operate and deliver municipal services, creating a valuable opportunity to assess the equity of these services in great detail. As applications such as Virtual Singapore, which uses a digital model of the entire island as a dashboard for municipal services, mature, national governments should encourage cities to regularly analyze the wealth of data they generate to forecast the impact new developments or services will have on their residents and to take steps to ensure that these developments serve their populations fairly.

CONCLUSION

National governments should recognize that cities acting alone cannot transition to smart cities as quickly or as effectively as would be desirable. To accelerate the development of smart cities, national governments should enact policies that address the key challenges to smart city development that cities are not likely to solve acting on their own. Nations that complement municipal initiatives with national government support will likely lead in smart city development and more quickly secure the social and economic benefits of smart cities.

TABLE: SUMMARY OF PROBLEMS LIMITING SMART CITY DEVELOPMENT AND POTENTIAL SOLUTIONS

Too Much Risk	
Problem	**Solutions**
Cities have little incentive to be early adopters of new smart city technology and bear all of the risk when they could instead wait until others have already worked out its challenges. Similarly, while public research and development (R&D) will be critical to the success of smart cities, a city cannot be expected to take on the costs of R&D in exchange for only a small share of the total benefits it will generate.	Invest in R&D for key underlying smart city technologies. Fund research and demonstration projects that develop and test smart city applications. Develop shared applications and tools to make cities better equipped to work with smart technology and data Support demonstration projects that establish comprehensive smart cities.
Lack of Focus on Smart Infrastructure	
Problem	**Solutions**
National government infrastructure investment focuses almost exclusively on enabling cities to develop “concrete and steel” infrastructure projects. This leaves little opportunity for more capable cities, which rely on national government investment, to pursue smart infrastructure built around “concrete and chips.”	Shift the focus of infrastructure investment from “concrete and steel” to “concrete and chips” by devoting portions of infrastructure spending specifically to digital infrastructure. Seek opportunities to invest in smart infrastructure where it can generate a higher return on investment for taxpayers.

The Need for Interconnected Smart Cities	
Problem	**Solutions**
If cities can share data with one another, governments can analyze larger pools of data, enabling more accurate and actionable insights. However, cities are not equipped to establish interconnected systems that span their jurisdictional boundaries.	Develop common tools, technologies, policies, and standards for collecting, storing, and analyzing smart city data. Implement incentive programs that reward cities for adopting these common standards and for sharing data and nonproprietary software tools with each other. Encourage the adoption of common technical standards that enable a "plug and play" approach to smart city development. Establish clear regulatory guidelines that maximize the utility of smart city data.
Lagging Communities of Practice	
Problem	**Solutions**
Smart city management and data-driven governance are significant changes from the normal way of doing things, and cities and communities need to be able to easily learn and share their successes and failures. Without systems to share this knowledge, progress will slow and cities will repeat each other's mistakes.	Encourage the development and adoption of smart city performance metrics to allow national governments to compare cities' performance using common criteria. Foster collaboration and coordination in the smart city ecosystem to facilitate inter-city learning and reduce knowledge-sharing barriers impeding the growth of smart cities. Use a variety of methods to build robust communities of practice for smart cities that integrate industry, government, and academia.

The Need to Ensure Equity	
Problem	**Solutions**
Cities may not deploy smart technologies equitably, which can exacerbate inequalities and limit the efficacy of these technologies. Cities may also not be aware of or equipped to deal with unforeseen disruptions caused by smart technologies that disadvantage certain communities.	Ensure smart city funding prioritizes the needs of undeserved communities. Ensure that no population is excluded from smart city data collection and use. Collect statistical data about smart city deployment. Develop educational material to help cities assess and address equity issues. Ensure funding for programs that address the needs of underserved communities, such as accessibility programs, emphasize the use of smart technology.

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