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SMART CITIES: HARNESSING REGIONAL INNOVATION NETWORKS AND GLOBAL COLLABORATIONS

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Smart Cities:

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Information technology and computer science move at a lightning pace, both literally within the electromagnetic spectrum and figuratively as a professional field. This continuous evolution affects technical experts in their professional development, project managers in their timelines and ever-moving targets, and program founders who shape the initiatives themselves. No professional can reliably predict where the next technological innovation or new application of existing capabilities will occur. In response, experts employing information and communication technologies (ICT) in large systems must always consider timelines of future developments and adhere to structured management practices to meet deadlines. Comparative advantage in the market drives technology adoption and go-to-market strategies, yet practically no company maintains exclusive control of entire production lines—from hardware engineering to end-user implementation. Instead, the global supply chain within an industry vertical achieves market efficiency by developing hardware and eventually delivering goods or services to the user. These experiences shape practitioners' approaches to smart city initiatives.

Many of the same issues facing ICT professionals are also found within public policy. Similar to the market pressures often felt within ICT enterprises, political leaders have a continuing interest in satisfying their populace. Large political systems and programs require structure and oversight to reliably maintain and shape society. Monitoring and evaluation practices ensure mandates are fulfilled and avoid negative stigmas of ineffective governance. When issues are detected, the government ideally employs comparative expert working groups to guide and shape policy according to lessons learned elsewhere in the world while continuously accommodating public input. This deliberate reformation process defines a path forward and the government evolves into more improved renditions. Just like the division of labor and specialization in the technological field, practitioners in government all have different backgrounds, which shape their approaches to smart city initiatives as well. Still, while governance and ICT

fields share similarities in management and system thinking, they are divergent in core knowledge.

Government officials often appear to know the least about ICT and there is little crossover study between the social and computer sciences. Though many technology professionals increasingly interact with fields outside of ICT as the market chain approaches the end-user level, collaboration is often segmented towards either highly specialized or generic user applications. This often creates a niche market while, in contrast, governments serve society as a whole. As the technology is integrating into a complex environment, bias towards reflecting on cities' complexity instead of merely inserting technology into parts of the city is recommended to facilitate holistic planning (Fernández-Güell et al., 2016). The various actors constituting a municipality all have different responsibilities by design. Though functions of government are intended to be complementary, installing technology into one area of responsibility will generally not benefit the government across the board. Public relations departments are separate from transportation services while water treatment systems are thankfully isolated from electrical infrastructure—not to mention the added complication of approval processes in committees and councils. Divisions in the public service sector present a dilemma where the implementation of smart city designs must understand each public service on the ground level while also successfully navigating the leadership structure within the framework of the government's overall functions. If each service area attempts to integrate smart city strategies for its particular purpose, overlapping problems pass unnoticed and costs become impermissible. This fragmentation threatens miscommunication and disdain for technological integration within each the bureaucracy, leadership, and public.

To bridge gaps between ICT and municipal government practitioners, the use of an isolated forum creates a buffer space for innovation, planning system interconnections, and big-picture frameworks. This isolates innovation processes from political perceptions of failure and consolidates resources, to including personnel, in developing a comprehensive and viable smart city framework. Information sharing between agencies is often the bane

of government systems while stove piping threatens a technocratic disconnect, driving wedges between communities and their leadership. This article explores potential regional innovation networks and global collaboration, as well as how such networks and collaboration can remedy divides in smart city knowledge gaps, design, and implementation strategies. Collaboration not only prevents these issues but allows new insights and capabilities to fruition in their absence.

Designing Regional Innovation Networks and Global Collaborations

Regional Innovation Networks serve as cooperation platforms by combining multiple actors from divergent fields and bridging their capabilities to generate new knowledge. This carries a strongly interdisciplinary approach that intentionally lacks substantial foundation and ultimately targets self-transcending knowledge, or the "ability to sense the presence of potential, to see what does not yet exist (intuitions and hunches)" (Uotila & Melkas, 2008, p. 225). Allowing non-standard configurations between preestablished operations allow practitioners to gather and process data, identify problems, find solutions, and plan implementations together rather than separately. This avoids fragmentation by approaching data with a wider core knowledge than available in traditional working environments. As decades passed, it became increasingly clear even before the proliferation of smart cities that innovation networks significantly depend on quality data input to reach quality results (Uotila & Melkas, 2008, pp. 225-233). Though platforms were originally deployed within multinational business environments, data harvesting from society and public service systems now allows innovation networks to analyze complex environments, such as municipalities, with greater success.

Governments increasingly utilize open innovation (OI) strategies to link businesses together and stimulate development, but the actors constituting these structures will still influence the outcomes. While regional innovation networks often operate at prohibitively high levels for small- and medium-sized enterprises, additions of lower-layer networks proposed as Local Open Innovation (LOI) offer an intermediary avenue for smaller businesses to still give development-oriented input (Leckel et al., 2020). While the

specialized knowledge to solve problems is likely unavailable to enterprises with limited resources, buy-in on both solutions and identification of thematic problems among otherwise isolated businesses are invaluable for guiding the regional network. The inclusiveness of any OI program is vital for community support, and in the cases of smart cities the public is the most important stakeholder. The public also posits the most sensible starting place for any government to begin implementing smart city systems. Within knowledge economy studies, incorporating the public into innovation networks is known as the quadruple helix model and forms an exchange between academia, industry, government, and civil society (Höglund & Linton, 2017, p. 61).

The reason the recommended model includes the public is simple: the basic function of the municipal government is to provide public services. Focusing on the human rather than the system in smart city innovation is shown to unlock new connections between the officials and residents. Known as user interface (UI) in computer programming, smart city initiative success could hinge on mastering engaging and intuitive designs when actors are engaged through projects. For example, an issue reporting app in Boston, Massachusetts saw great success through requesting pictures of potholes, graffiti, and other public works issues in the city and later responded to citizens' reports as they were resolved in real-time—even showing the city workers who corrected the issue to further humanize the process (Nigel, 2017). Following a resident-centric approach also ensures socially reported issues receive attention rather than only theorized concepts. Even if the quadruple helix model is not employed at every level, the inclusion of data security and privacy rights advocates should be included in any planning process to at least prevent inadvertently harming the public and losing its trust. Monitoring and minimizing the digital divide—any segment of the public that is isolated from ICT systems—is additionally important to ensure sufficient input mechanisms are available for all populations to be heard.

Incorporating the public may yield more effective governance, as well. eGovernment programs use technology to better connect political leadership with citizens but additionally offer a data-feeding mechanism for OI initiatives. These allow real-time public feedback for experts as future projects undergo design and implementation processes. All stakeholders involved must remember that despite businesses and officials holding legitimate and specific interests in solving issues, the public is the most important actor involved within any polity and some region's governments have responded in-kind. As government structures exist at multiple levels within a regional environment, these frameworks are also easily scalable for other representation bodies. However, a larger footprint increasingly poses a larger target for cyberattacks. To convey how eGovernment systems have spread between 2016 and 2020, Figure 1 depicts eGovernment program prevalence ranked by world region. European countries currently lead with high scores on the United Nation's eGovernment development index, guaranteeing enhanced communication between municipalities and their residents (UN Dept. of Economic and Social Affairs, 2020, p. xxvi).

Working through Regional Innovation Networks is not limited only to technological innovation but also contributes to regional development. Metropolitan areas that connect to regional cities, towns, and villages create an ability to plan for connecting smart city systems as part of larger grids and generate more income. Similar to the private and civil society sectors, facilitating dialogue between sub and supranational governments brings regional needs to light for the region to grow as a whole while uncovering interconnected problems. Regional development in both business and tourism-centric enhancements grow increasingly important as urbanization continues to drain rural populations worldwide (UN Economist Network, 2020, pp. 71-101). As cities grow in population and infrastructure needs, regional programs can reduce costs and promote uniform adoption across municipalities. Smart grids in energy, tele-communications, and transportation are prime targets for regional programs (Vadari, 2018, pp. 313-330). The outcome of grid systems is often underwhelming when approached only from a

technological standpoint—partially because of private interests often defining the parameters at the expense of the public (Lovell, 2017). As stated in the introduction, the dilemma is to understand each ground-level operation and the operating environment, from personnel structure to physical landscape. People cannot be forgotten, and this includes city workers and marginal populations, as well. Smart grids often require entire revolutions to the working practices of the local industry and the installation of new control devices to gather data and guide ongoing decision-making processes.

Figure 1

Regional distribution of countries by eGovernment Development Index (EGDI) level
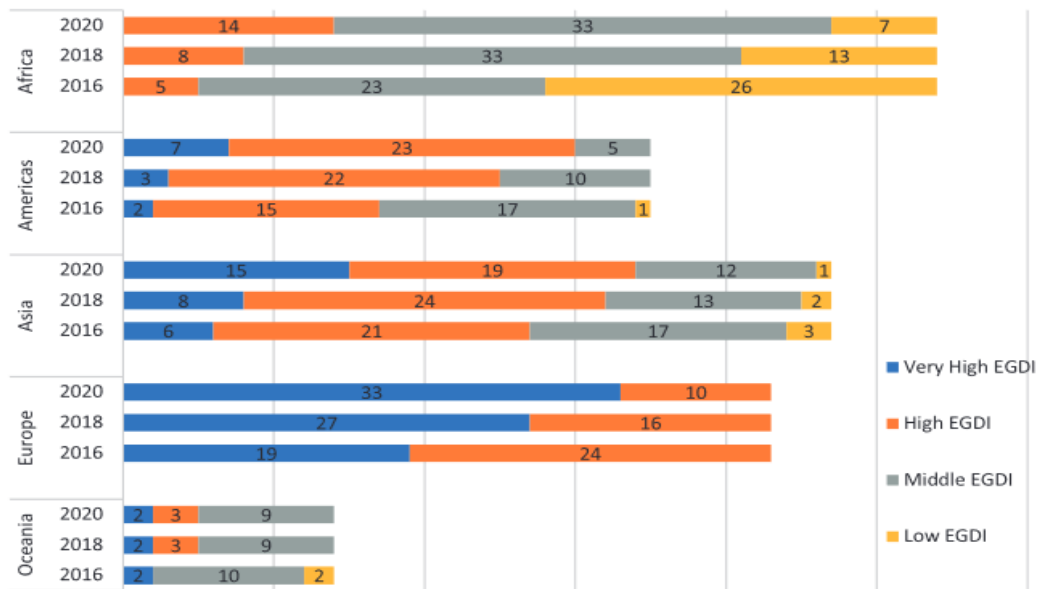
Note. Figure 1 depicts biannual changes assessed by the United Nations Department of Economic and Social Affairs measures quality of eGovernment services in the regions of the world The report additionally lists percentages of countries in the highest EGDI level: Europe (58%), Asia (26%), Americas (12%), and Oceania (4%) (UN Dept. of Economic and Social Affairs, 2020, p. xxvi).

For energy grids, the implementation of microgrids can bring resiliency to regional infrastructure by allowing local systems to engage (grid-connected) and disengage (island-mode) from the greater energy grid depending on the situation (Vadari, 2018, pp. 131-160). Microgrids are a self-sufficient energy system that service a small area, such as a college campus, and differs from a macro-grid model that services municipalities or larger ones. The use of microgrids allows local selection between energy generation sources in reaction to environmental conditions and resource availability. Other factors, such as political divisions, may be eased with the flexibility this offers local governments despite local borders. Long-haul energy infrastructure is inefficient and costly compared to local power generation practices due to line losses. Distribution network transformers and cables account for the highest inefficiency loss levels in electrical grid systems, which were further found to be three times higher in developing countries as compared to the European Union (EU Public Group on Energy, 2016, Module 5.5). Regardless of local levels of development, microgrids offer particularly ideal options for communities that desire resiliency from disruptions such as extreme weather events (Vadari, 2018, pp. 131-160). Building local infrastructure isolated from the macro-grid is also beneficial to national security—in the event of service disruption due to a cyber-attack or military activity, the affected microgrids can be isolated or re-routed, offering increased resiliency.

Though only eGovernment and smart grids were mentioned for the design of Regional Innovation Networks, applications of innovation systems are practically endless for the complex city environment. The overall function of regional forums is to facilitate the innovation process with a diversity of actors in a centralized environment that contains the necessary expertise to develop smart city systems; we should not assume any individual or single organization has the best answers. For these innovations to be leveraged worldwide, open information sharing between cities, governments, regions, and organizations offers stakeholders quality data to create innovative solutions to today's problems. The next section expands the notion of regional cooperation and includes any

global collaboration practices to show how programs are already implementing these practices.

Regional Innovation Networks and Global Collaborations Frameworks in Practice

Every continent has smart cities and global award listings are widespread (Smart Cities Connect, n.d.; Smart City Expo, n.d.; ICF, n.d.). While innovation initiatives between cities exist, it is still an emerging field that appears to focus on data sharing and smaller pilot programs. In the absence of a specialized forum for regional innovation, the creation of government-originating challenges drives much of the collaboration worldwide. Public and private partnerships are common in these programs, but the inclusion of the public is generally lacking due to their more business-oriented approach. The past approximately half-decade saw the proliferation of top-down strategies to develop framework approaches to guide more widespread adoption of smart city plans. The driving force behind frameworks is scalability as a reaction to global fragmentation between city initiatives. Once a framework is complete, it should be easily adoptable by new cities; the more advanced frameworks additionally promote common data practices, allowing platform interoperability and efficient data sharing and analysis. This movement is global as may be seen with ASEAN's release of their Smart Cities Framework in 2018 (ASEAN, 2018). Singapore and Malaysia both developed frameworks of their own and depict how a regional spread may result from smart city hubs (Smart Nation, 2020; KPKT, 2018).

A more comprehensive multi-national plan was hatched by the European Union's SynchroniCity program, co-funded by Switzerland and South Korea (Synchronicity, n.d.). Synchronicity follows the Brussels, Belgium-based Open and Agile Smart Cities (OASC) organization in its mission to unite communities around the world under the developed Minimal Interoperability Mechanisms (MIMs) which prioritize the establishment of (1) context information management, (2) common data models, and (3) marketplace enablers (ecosystem transaction management) (OASC, n.d.b). With an apparent focus on data sharing and partner city pilot programs, innovation efforts include traffic data management and street light activation, tracking waste management practices, monitoring urban noise

effects on public movement, air quality testing, bicycle theft, and eGovernment applications (Synchronicity, n.d.). The most involved cities are Calatayud (Spain), Antwerp (Belgium), Porto (Portugal), Carouge (Switzerland), and Helsinki (Finland). Many of these same initiatives may be seen on OASC's website currently in development which contains its own catalog of smart city solutions and details profiles for its seventeen member cities (OASC, n.d.a).

While regional smart city approaches within the United States reportedly focus more on traditional functions of government, such as jobs and industry competitiveness along with affordable housing and transportation, the federal government's National Institute of Standards and Technology (NIST) hosts a Global City Teams Challenge (GCTC, n.d.; MTI, 2019, p. 44). Domestically, innovative smart city applications exist within municipalities, but U.S. regional smart city strategies are limited and focus on urbanization effects pushing poor citizens out of city centers and into the suburbs (MTI, 2019, p. 72). According to experts interviewed, the programs tend to be politically vulnerable without key officials serving as champion figures to support their continuance in the area. This suggests the need for a common proven narrative showcasing how smart city strategies are beneficial to regional applications.

The Global City Teams Challenge (GCTC) first launched in 2014 and aims to develop and deploy standard-based solutions that are scalable, replicable, and interoperable (GCTC, n.d.). A Smart Cities and Communities FrameworkSeries has additionally published a framework for worldwide use (SCCF, 2019). The GCTC has grown recently incorporating multiple U.S. governmental departments; the platform is mostly externally facing, effectively creating a Regional Innovation Network structure between diverse actors. The program boasts some "200 Action Clusters, involving over 200 cities, and 500 companies, universities, and non-profits" with forty percent being foreign based (GCTC, n.d., para. 5). It runs an annual GCTC Expo and a Global Tech Jam attracting multinational tech conglomerates while receiving funding from NGOs as well as the Italian and South Korean governments. Showcased innovations include artificial intelligence analysis of

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road repair imaging in Maryland, U.S., biofuel production in Nigeria, light pollution reduction in Ireland, environmental disaster monitoring in Turin, Italy, and public building energy usage in South Korea.

Challenges and Opportunities in Smart City Cybersecurity

The use of smart-city infrastructure comes with its share of challenges. While municipal services are able to operate at machine speed, so can cybersecurity threats that could disrupt or deny services to the public, steal information, or conduct espionage on a city's way of life in preparation for further military action. A recent (April 2021) study conducted by researchers at the Peter the Great St. Petersburg Polytechnic University examined the cybersecurity risk assessment process for smart city infrastructures and noted some extreme challenges with traditional human-centric approaches to cybersecurity. The study concluded that use of traditionally calculated risk estimation using existing standards, such as BS 7799-3 or the U.S. National Industrial Standards and Technology (NIST) special publication 800-30 methodology, lacked usefulness in a "mobile inter-device network of the smart city"—specifically due to the scale and scope of the systems-of-systems and data in use (Kalinin, et al., 2021).

Given the extreme cyber risk that could accompany a smart city, Regional Innovation Networks and the use of global collaboration offers some important tools such as faster cyber threat intelligence sharing, attack detection, and system isolation at machine speed. The need for smart cities to protect their data infrastructure using automated cybersecurity tools and techniques cannot be understated while keeping a "human in the loop" to ensure strategic action and communication remains centralized. The use of microgrids in energy grid planning, as stated previously, allows the system to self-isolate in the event of a failure or detected cyber-attack, and the use of Regional Innovation Networks can quickly alert municipalities to the breach to prevent systemic failure across a macro-grid.

Conclusion

Regional Innovation Networks and global collaboration within smart city strategies is an emerging field that has yet to come into full force. Until designs begin to incorporate more data sharing frameworks such as that being established by the European Union and United States government, initiatives are likely to stay segregated within their municipalities. This chapter described how a quadruple helix model has promising benefits for equity within smart city frameworks and displays particular promise for each eGovernment program, smart grids, and data sharing. Including the public as a fundamental stakeholder in frameworks ensures privacy and digital rights will not be undermined while innovation strategies develop new knowledge in politically isolated, stand-alone environments. If municipalities and their surrounding regions are able to establish common working parameters, the future of smart city interoperability and cooperation will lead to an explosion of data harvested from citizens worldwide. Experts will finally be armed with quality data to plan new resiliencies and strategies for governments to employ as the world's cities continue to expand during the foreseeable future.

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