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Exploring the 'Smartness' of city in COVID-19 responses through the agile innovation model: How did Daegu flatten the initial curve?

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Abstract The COVID-19 crisis has tested the preparedness of cities across the globe. Confronting the challenges, how cities respond to this crisis to maintain economic resilience has attracted much attention. To situate smart city in evolutionary economic geography and stretch it toward the agile innovation model, this study examines what smart city actually do better. We explored the initial COVID-19 response process in the city of Daegu, South Korea as the model of a smart city. We demonstrated that 'smartness' of a city is established from the cumulative outcomes of layered experiences rather than constructed from scratch. This research contributes to expanding the scope of urban resilience literature through the agile model, as a part of the evolution approach, which builds a region's competitiveness backed up and accelerated by urban ICT infrastructures.

Keywords: agile city, smart city, urban resilience, Daegu, COVID-19

I. Introduction

The global economy has experienced several crises from the Great Depression of the 1930s to the COVID-19 pandemic threats (Tsilika et al., 2020). While it is too early to conclude that the COVID-19 crisis has totally terminated, it is undoubtedly one of a critical impact across the global economies. The rapid epidemic spurred governments to intervene across social distancing policy, infection control, medical treatment, border control, public health care service,

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and fiscal policy, all of which triggered calling for new unprecedented experimentations. Cities, at a juncture with the epidemic centre and recovery control tower, invoke the lexicon of urban innovation by enabling orchestrated local government policies during and beyond the pandemic crisis (Connolly et al., 2020; McGuirk et al., 2020; Nathan, 2020). For instance, Sonn and Lee (2020). emphasized the effective utilization of three smart technologies – card system, smartphone and CCTVs – to control the large outbreaks at the initial stage. The effective initial treatment contributed to reinforcing state power to control the consequent threats by which the policy practitioners could minimize the negative impact on the economy.

The recent COVID-19 crisis has tested the smart readiness of response systems and the feasibility of new technologies in the cities. The smart city contributes to explaining how some cities controlled the pandemic effectively and maintained the core functions. Smart technologies have reduced physical distance, increasing the spread of the virus via respiratory infections and, at the same time, offering alternative methods to control the infections (Sharifi et al., 2021). A few topics, how cities respond to this crisis, have drawn attention in the process of tracking confirmed cases (Pan et al., 2022; Sonn & Lee, 2020), local governance (McGuirk et al., 2020), agility (Mergel, 2016), resilience (Portuguez Castro & Gómez Zermeño, 2020) and smart city implementation (Bonetto & Rossi, 2017; Kummitha & Crutzen, 2017).

Although we are not diminishing the importance of digital data as policy means to rationalize the management of cities, such smart city-oriented studies fully addressed the fundamental assumption of a smart city where the ultimate goal is promoting economic viability or, at least, preventing the deterioration of the dynamics of the urban economy. It is interesting to find a new implementation of emerging technologies in city management and "new smart city stories built from scratch which as-of-yet have often failed to materialize smartness" (Shelton et al., 2015, p. 14). Yet, we find it more useful to examine how the data-driven cities approach reconciles the resilience of urban economy by responding to the pandemic crisis in more agile ways (Gutierrez & Landa, 2022).

In this article, rather than the idealized but unrealized image, we seek to present a theoretical lens to understand what existing smart cities 'actually' do better during the crisis and conceptualize the cumulative process of developing the competitiveness of the smart city. To this end, we reviewed the city of Daegu's case, widely recognized as a smart city model in South Korea, and examined what the government's policies were, how they were developed as a responsive action according to the stages, and what the consequences were.

Given that periodical waves of new technologies were connected to fads and fashions, and historically, COVID-19 was not the only crisis that the city has undergone, this article focuses on the process of how a smart city contributes to

urban resilience and how a smart city has become more agile to respond to the threats than before. We also introduce an agile innovation model to capture the evolutionary and cumulative development of repetitive cycles by which the existence of such evolutionary initiatives is largely seen as a means of smartness of a specific region.

The rest of the paper is structured as follows: Section two presented the analytical framework based on agile approaches originating from software development methodology, then applied it to smart city approaches. In section three, we analyzed the consecutive responses to Daegu's COVID-19 crisis in accordance with the four phases of the agile city framework – (1) Design (Exploration), (2) Experiment, (3) Deployment, and (4) Feedback (Upgrade) – and then derive implications. Section four concluded the study along with discussions and policy recommendations.

II. Urban resilience and Agile approach

1. *Smart city approach as an urban resilience model*

The academic field of urban planning has been created by sanitation and public health issues in Western Europe (Jones & Evans, 2013). It has not only responded to diverse types of urban problems but also even adapted and evolved by itself (Meerow et al., 2016; Raco & Street, 2012). Such consideration has been developed into to the concept of urban resilience. The idea of urban resilience was introduced in the field of ecology by a Canadian theoretical ecologist, Crawford Stanley Holling, who asserted a distinction between engineering and ecological resilience (Davoudi et al., 2012). I has been expanded in the field of social science including psychology, environmental planning, disaster studies and economic geography. Researchers in each academic field separately define the meaning of resilience such as: the capacity of a city which is revitalized from urban destruction (Vale & Campanella, 2005); the capacity of equilibrium (Simmie & Martin, 2010); and the ability of systems to localize, adapt and evolve in response to stresses and strains (Folke et al., 2010).

The idea of urban resilience does not mean the ability of complex socio-ecological systems to return to normality but to become evolved. In this background, researchers in urban planning particularly concentrate on evolutionary resilience. They believe that urban planning is a preparation for 'innovative transformation at times of change and in the face of inherent uncertainties' (Davoudi et al., 2012, p. 304). The smartness of the city, a new method of urban planning in the future, enables us to deal with such inherent

uncertainties (diverse urban problems) through a process of evolutionary resilience. This leads to meeting the ultimate aim of urban planning in the current era with urban resilience (Büyüközkan et al., 2022; Zhu et al., 2019).

As one of the newest agendas in urban planning, the idea of a smart city has become famous across the world since the 2010s (Harrison & Donnelly, 2011). The term 'smart' was initially adopted by Information & Communications Technology (hereafter, ICT) industries such as CISCO (2005), IBM (2009), and SIEMENS (2004) in order to integrate urban infrastructure and complex information services. On the other hand, in the academic field, a smart city can be commonly defined as the emerging, future version of the city, 'collections of numerous sentients and connected built environments, which possess components that learn from patterns of daily activity and adapt automatically to changes in such behaviours' (Batty et al., 2012; Kandt & Batty, 2021, p. 2).

The concept of a smart city enables the suggestion of new insights for a sustainable urban society, in line with urban resilience, through urban practices, which improve cities' carrying capacity and disaster resistance (Tzioutziou & Xenidis, 2021; Zhou et al., 2021). In other words, a city can be improved in a sustainable way through intelligent approaches with digitalized resources and devices. In detail, smart city initiatives such as smart solutions and technologies, as a 'time-space cartographer' (Sonn & Lee, 2020), provide a number of opportunities for enhancing resilience and surveillance by predicting pandemic patterns and by facilitating a timely response (Hassankhani et al., 2021; Rajabifard & Foliente, 2021; Yang & Chong, 2021). For instance, diverse applications by using Information and Communication Technologies (ICT) and the Internet of Things (IoT) are explored in case studies (Hassankhani et al., 2021; Rajabifard & Foliente, 2021; Yang & Chong, 2021).

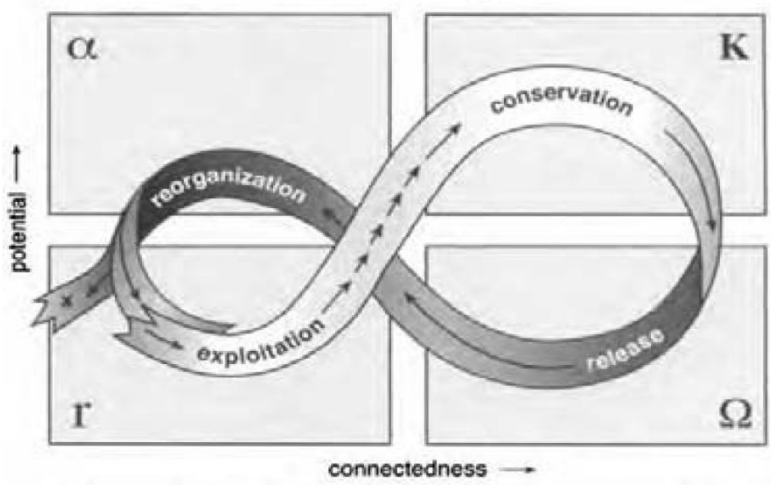
From the academic field of urban planning, the idea of a smart city is far from a totally new one. Nevertheless, when the smart city approach is supported by urban science – as a rational method by collecting, monitoring, and integrating data, e.g., urban resource management systems such as energy systems (Bonetto & Rossi, 2017; Zhou et al., 2016) and emergency response (Cook et al., 2018; Palmieri et al., 2016) – the interventions may leave a certain novelty value. In this context, we argue that the smartness of the urban area comes from the evolutionary (which can also be mentioned as a novelty) outcomes of existing social and spatial constellations of urban governance and the built environment and are not based on tabula rasa in the plan of some governments.

2. Toward Agile approach in the city

To address the above literature more practically, we are trying to use the COVID-19 response, as the resilience capacity model, which is rather an

evolutionary process than one built from scratch. We assume that a data-driven smart city is the cumulative outcome from past experiences moving toward a more competitive region. To explain such characteristics with evolutionary resilience, we borrow the economic geographer's metaphor of the adaptive cycle, so-called the Panarchy Model of Adaptive Cycle (Gunderson & Holling, 2002, p.34, Figure 1). It analyses social innovation into four phases: (1) reorganization phase; (2) exploitation phase; (3) conservation phase; and (4) release phase. The first and second phases are the time of greatest uncertainty yet high resilience. The third phase stands for a time of innovation and transformation. Finally, in the last phase, a crisis can be turned into a new opportunity.

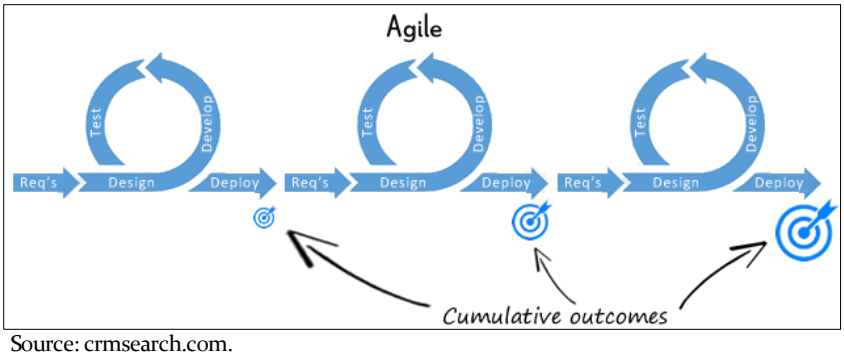
However, such an interpretation about the smartness of a city is not sufficient and should be revised for an actual case study. In particular, it cannot explain one of the main characteristics of a smart city in the current era within which the city can swiftly react against complex urban problems based on the data-driven approach (Liu et al., 2022). Moreover, positive outcomes accumulate through social innovation over time. To explain such circumstances, the Panarchy model should be shrunk (time), developed (the level of performance) and enlarged (the scope of research area). Going beyond the traditional model, this research suggests introducing the 'agile' model (Highsmith & Cockburn, 2001; Ismail et al., 2011; Mergel, 2016; van Bree & Bouma, 2017), originating from the field of software development.



Source: Gunderson & Holling, 2002, p. 34

Figure 1. The Panarchy Model of Adaptive Cycle

Agile approaches (Figure 2) originate from the field of software development and Open Government Data (Mcbride et al., 2018). It is a methodology that involves creating, testing, and improving technology products incrementally. The agile approaches are distinguished as fast and responsive processes (Martini & Bosch, 2016), and more importantly, they have evolved over time (Beck et al., 2001). Through the evolution and development of repetitive cycles, cumulative outcomes have become improved (Soe & Drechsler, 2018). The agile approaches can be completely applied to complex issues when the final solution is uncertain – especially in environments like the cases of government (Rigby et al., 2016).



Source: crmsearch.com.

Figure 2. The Model of the Agile approach in the field of software development

In the urban perspective, van Bree and Bouma (2017) used the term 'agile city', as defined as 'an agile or adaptive city is in a position to keep its region economically vibrant, lively, and accessible within the context of societal challenges, fast-moving technological changes, and fundamental uncertainties' (pp.2). Crucial elements here are looking ahead, experimenting, learning, and being flexible. This applies to all urban members – not just to regional administrators, but also to companies, knowledge institutions, and citizens. We believe that this fits very well in all current urban circumstances, particularly when the smartness of a city is explored.

Thus, this research will analyze essential characteristics of the idea of the agile approach, demonstrate them through the empirical case study and suggest it as a new city model, which is more adaptable for interpreting the smartness of a city compared to the conventional conceptual terminology, a smart city. The concept of an agile city stands for the smartness of a city where social innovation occurs repeatedly with the phases of experimenting, evaluating, and upgrading in order to resolve urban problems within complicated contexts. Through the innovative cycle, data have been stored over and over and every stakeholder

enables the customization of such data for individual purposes particularly aiming at social innovation. In the agile city, all urban issues and services are developed and tested constantly, improvements are also made and tested throughout development, and if mistakes are made, they are learned from and used to improve quickly (Mcbride et al., 2018).

II. Data and Analysis

1. *Data collection: Daegu Metropolitan City, South Korea*

This study uses the empirical case of the Daegu Metropolitan City, South Korea. The Daegu Metropolitan City, located in South-eastern Korea (Figure 3), is the 3rd largest city in South Korea with around 2.5 million residents and an area of 883.70 square kilometers. The city was the growth machine (Molotch, 1993) of South Korea from the 1960s to the 1980s. The major industries of the city were textiles, metals, machinery and electronics industry. However, due to industrial restructuring since the 1990s, the local industries have decreased and the local government has endeavoured to develop the city with high-technology-led industries, a so-called 'smart city' (Jo et al., 2021) in these days.

Source: google image

Figure 3. Location of the Daegu Metropolitan City (source:)

Daegu, located in South Korea, has been designated as the symbolic city of the COVID-19 pandemic, as it was the site where the first confirmed case was

reported, which was linked to a specific religious cult. Despite facing such unprecedented challenges, the local government responded effectively to the pandemic using smart technologies. The present study aims to explore two primary phenomena, namely, the city's stability amidst the pandemic and the citizens' spontaneous recovery of their daily lives. Additionally, the study seeks to investigate how the city's rich history and context can be leveraged as a resource to interpret these phenomena as hallmarks of the city's smartness.

The study collected official documentation of the local government's COVID-19 response, policies, and programs from various sources, including the Daegu Metropolitan City, the Daegu Medical Association, Kyungpook National University Hospital, and the Daegu Technopark. Elite interviews were conducted with academic experts, civil servants, relevant organizations, and medical experts in medical institutions in Daegu using snowball sampling. The approach facilitated the identification of additional cases and generated valuable resources. The study will reference interviewee quotes by their positions and roles in their respective institutes to provide context and identify their impact on the case study. To express their significance, interviewees will be identified using vague employment descriptions.

2. *Analysis*

By the time COVID-19 had become a pandemic disease across the world, both the national government and local governments in South Korea were also concerned about the circumstance and considered proper manoeuvres. In particular, the city of Daegu became the most vulnerable to COVID-19 in South Korea due to the rapid spread of the global pandemic disease from a specific religious cult. This led to investigating the city government's response against COVID-19 and discussing the characteristics of the Daegu Metropolitan City as an epitome of an agile city. The following part is divided into four sections by interpreting the case of Daegu through four phases of the agile city framework: (1) Design (Exploration); (2) Experiment; (3) Deployment; and (4) Feedback (Upgrade).

Design (Exploration): The establishment of data-driven infrastructure/ extended network governance system

With the wide spread of COVID-19 around the world and its inflow to South Korea, the city government of Daegu endeavoured to respond against the global pandemic disease. To discover dangerous environmental changes and respond to the changes effectively and efficiently, the local government established both an online platform and an offline governance system. Through the two-way

systems, the Daegu Metropolitan City sought to manage the physical infrastructure and human resources in an integrated way.

The above two-way systems, particularly the experience of data collection and analysis, are invisible legacies from a couple of accidents in Daegu such as the Middle East Respiratory Syndrome (hereafter, MERS) outbreaks and the Daegu subway fire[1]. To prepare such additional issues, both national and local governments published a white paper (Seok et al., 2021a, 2021b, 2021c) which contained relevant policies, institutions and protocols about infectious diseases, accidents and disasters. Those collected, precedent data and critical analysis have become the very beginning of a new policy design. Moreover, with the development of high-technology, myriad data have been collected through ICT, real-time based, ubiquitous technologies and Social Network Services (hereafter, SNS). Scientific analyses based on such data have brought about data-driven policymaking, which has become a major tool of policy design in Daegu (Seok et al., 2021a).

Regarding the online system, the city government created the COVID-19 data-driven information sharing platform (http://COVID19.daegu.go.kr/). Diverse actors within the evolving governance system shared relevant information through such an online service. In particular, SNS within the online platform contributed to creating a democratic communication circumstance in the policy-making process. Individual departments within the Daegu Metropolitan City COVID-19 Emergency Response Centre raised any issues through the official SNS system. Such issues were officially collected, articulated and resolved by the Emergency Countermeasure Team. Regardless of the increasing responsibility in the workplace, the staff of each department could concentrate on their work (Seok et al., 2021a).

At 10 p.m. every night, the staff in all relevant departments participated in the meeting through the social network service created by the Daegu Metropolitan City government. This encouraged experts in the real world to make an effective and immediate decision by removing a bureaucratic process (e.g., documentation works). (Interview with a chief manager from Citizen Safety Office Bureau, Daegu Metropolitan City, 2022.)

In terms of the offline governance system, the city government changed the governance system in an extended network way from the Disease Control Department to the Daegu Metropolitan City Disaster and Safety Countermeasure Headquarters. As the Disease Control Department became an

1 This occurred on the 18th of February 2003, when an arsonist set fire to a train. As a result of the incident, 192 people died and 151 others were injured at a subway station.

integrated and systemic governance, it was able to respond against the local pandemic issues not only swiftly but also effectively.

Furthermore, from the 21st of February 2020, the Central Disaster Management Headquarters designated the city of Daegu as an infectious disease special management area. The Daegu Metropolitan City government began to run the COVID-19 Emergency Response Centre to establish a strict pandemic disease management system (Seok et al., 2021a, p. 45). The mayor of Daegu was responsible for the whole system. The Daegu Metropolitan City COVID-19 Emergency Response Centre was a practical group that consisted of civil servants from both central and local governments (Pan-governmental Special Countermeasure Support Team, Korea Centres for Disease Control and Prevention Rapid Response Team), private experts (medical institutions) and local medical administrators (Medi-City Daegu Council and Daegu Medical Association). They shared the idea or policy particularly concerning the management of COVID-19 patients (epidemiological investigation, classification of patients by severity, patients waiting for hospitalization and confirmed cases) in everyday consultation. This overcame time-consuming bureaucratic routines significantly (Y. A. Kim, 2022).

Experiment: The implementation of unprecedented approaches

The phase of the experiment initiates the establishment of an agile city loop. In this phase, every stakeholder can directly access, process, analyze the accumulated data based on the above two-way systems, and use it for the purpose of each group but with a common purpose, to solve urban challenges. Such diverse uses are rediscovered from the traditional approaches, which cannot fit and work well in the present, and would spontaneously become social innovations and unprecedented approaches. Moreover, the highly developed ICT and extended network governance system helped to improve and accelerate the implementation of such unprecedented approaches.

At the beginning of the COVID-19 outbreaks, the first ideal principle for the COVID-19 response was to secure lower population density among contacts. However, there were not sufficient facilities and medical manpower in hospitals. The official data described that 449 patients were infected (of a total of 1,011 patients, 44.4 %) and 67 patients of these died during the cohort isolation in six hospitals (H. D. Kim, 2022). In this circumstance, the Daegu Metropolitan City government decided to operate the Daegu Public Quarantine System based on real-time data analysis with an accumulated past dataset in the field of medical management. The Daegu Public Quarantine System is a monitoring system for close contacts. If there was a new confirmed case in a convalescent hospital and the patient might be at risk of cross infection, the patient was transferred to a public hospital which enabled infection management. This unprecedented approach enabled to secure a certain number of medical staff and beds at least.

Under the new system, the percentage of people testing positive for COVID-19 was 12.3 %. This is much lower than the ratio in the past, which was 44.4 %. Furthermore, the system shortened the isolation and quarantine period from 44.5 days to 18.4 days on average (Jeong et al., 2021). This led to preventing mass infection, minimizing the risk of cross infection, increasing the effectiveness of negative pressure room management and decreasing the medical manpower's tiredness.

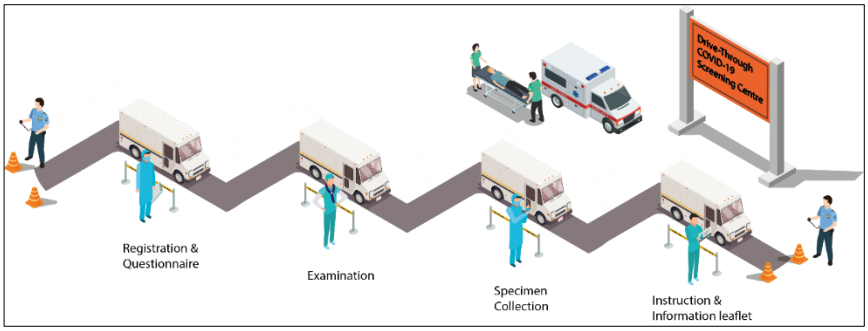
Another innovative approach is the No-contact Classification of patients by the level of severity. Due to the shortage of available hospital beds based on collected data, this was introduced promptly on the 27th of February 2020 by the Daegu Metropolitan City government (Seok et al., 2021b, p. 34). The system classified patients' severity based on the integrated data (monitoring symptom cases) registered by the Infectious Disease Management Support Team with underlying medical conditions registered by the National Health Insurance Corporation. The result prioritized hospital admission of patients affected by COVID-19. Regarding monitoring symptom cases, 165 volunteers (medical doctors) from the Daegu Medical Association collected patients' status under self-quarantine and counseled them online. Their diagnoses were registered and synchronized for the public good (Jeong et al., 2021).

Lastly, a number of well-known practices, such as an open access system regarding information on confirmed cases' routes, drive-through and walk-through screening stations, were established for the first time in Daegu. Since the outbreaks began in the city, the local government endeavoured to protect citizens from the vague dread of infection, encouraged citizens to respond against COVID-19 proactively and secured a certain level of a local medical treatment system even in the chaotic situation. All those innovative and unprecedented approaches finally developed into national policies or programs so that the city of Daegu became a test bed for diverse innovative COVID-19 responses.

In detail, the Drive-Through Screening Centre (hereafter DTSC), located near the city centre in a small area, provided an unprecedented experimental opportunity for the screening system. The brief flow of the DTSC is as follows: Entrance – Registration – Examination – Specimen collection – Instructions – Exit (Figure 4). The entire service is provided to testees without leaving their cars. All communication can be made through a mobile phone except for the specimen collection. The use of an electronic payment system allows minimal contact between the testees and the staff. The DTSC was firstly suggested and implemented on February 23 2020 at Kyungpook National University Chilgok Hospital. As it proved to be safe and efficient for COVID-19 screening, the system was circulated across the country. In total, 577 DTSCs have operated in South Korea (as of March 12, 2020). It usually takes about 10 minutes per test, which is one-third shorter than the conventional screening process. Furthermore,

such newly collected and analyzed data with relevant reports were stored and used for the invention and development of unprecedented methods for the future.

We were super busy at that time. However, we had to figure it out. We did our job from a sense of responsibility, conducting ourselves as the last gatekeeper against COVID-19. The inflection points about COVID-19 brought somewhat relief (Interview with a senior officer from Safety Policy Officer, Citizen Safety Office Bureau, Daegu Metropolitan City, 2022).



Source: The Korean Society of Infectious Diseases – contents, Freepik – pictogram; revised by Author

Figure 4. Drive-Through COVID-19 screening centre illustration

Deployment: Sophisticatedly localized approaches

As the COVID-19 outbreaks started, the South Korean government planned to control all policies and institutions regarding COVID-19 nationally. The national government aimed to secure enough medical staff and facilities for efficient and effective hospitalization. After the MERS outbreaks in 2015, every infectious disease patient must be hospitalized in a negative pressure room. For instance, on the 29th of February 2020, the Central Disaster and Safety Countermeasure Headquarters on behalf of the central government did not fully publish a quarantine plan. Since around 80 % of patients were mild symptom cases, the national government believed that the patients could recover by themselves with the minimum medical treatment such as a fever reducer and pain killer. The central government thought such self-quarantine and self-treatment would bring about the security of sufficient medical facilities and staff for severe symptom cases (Jeong et al., 2021).

However, the local government and medical staff in the Daegu Metropolitan City disagreed with the national government's perspective. Based on real-time data collection and analysis, such a theoretical plan could not fit well in the harsh local context. In the city of Daegu, there were 54 beds and 33 negative pressure

rooms. Only three days after the first confirmed case was discovered, every other bed in Daegu was fully occupied. The medical service in Daegu was in danger of collapsing. Since COVID-19 spreads too fast, the current national systemic approach did not work in practice (Seok et al., 2021b, p. 32). Regardless of the central government's efforts, the shortage of medical infrastructure and staff became inevitable. The Daegu Metropolitan City government requested the national government to change the rule of hospitalization for infectious disease patients. After all, on the 1st of March 2020, the Central Disaster and Safety Countermeasure Headquarters began to consider the revision of current national policies and institutions regarding COVID-19. In this context, the world's first residential treatment centre was introduced. The Daegu Metropolitan City government cooperated with six ministries in South Korea and other cities and finally operated 15 residential treatment centres. In emergencies, the city government was fully responsible for the operation of the centre so that it was able to make a decision efficiently.

To use the residential treatment centre effectively in the local area, the Daegu Metropolitan City government also created a patient classification system by severity. Medical staff conducted a medical check-up for new inmates through a COVID-19 Health Screening Questionnaire (Y. A. Kim, 2022). Based on the classification system, mild symptom patients were isolated in the designated residential treatment centre with proper medical monitoring services and treatments. On the other hand, the severe symptom cases were transferred to a negative pressure isolation room or hospitals dedicated to infectious disease. This practical system, developed in a local area, significantly improved the constant monitoring of hospital admissions, patient flow within a hospital and the identification of the availability of beds across wards. Moreover, all such records were kept, managed and shared for medical purposes for the future.

Furthermore, for the precise epidemiological investigation, the Daegu Metropolitan City government introduced the first version of a digitalized infectious disease prevention and control system in South Korea. As a number of epidemic intelligence (service) officers were required, the local government planned to establish an online version of them. For instance, the city government installed an electronic access list system, which was based on a QR check-in function, in public spaces such as the Daegu Metropolitan City Hall, Daegu Art Museum and amusement parks. The Daegu Metropolitan City government also supported local educational institutions to secure a certain level of an epidemic intelligence service including an electronic access list system and a self-check mobile application. This significantly helped disease control authorities to respond to COVID-19 swiftly (H. D. Kim, 2022).

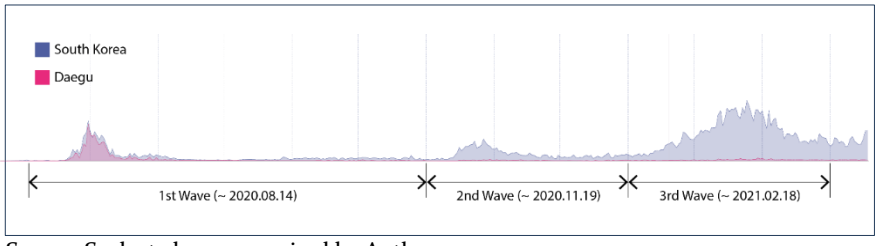
Interestingly, in terms of the self-check mobile application, it was empirically adopted, tested and revised in the Daegu Metropolitan City and finally evolved into a national medical protocol, symbolizing the epitome of 'Korea's response

to COVID-19'. Consequently, there were only institutional and political responses to COVID-19 by local areas, not extreme measures by the national authorities such as lockdowns in other countries.

Feedback (Upgrade): Creating a Virtuous Cycle

The last stage, feedback, led to creating a virtuous cycle regarding the COVID-19 response in the Daegu Metropolitan City. After the first confirmed case was discovered, the number of confirmed cases rapidly increased; in the first wave, a period from the midst of February to that of August (Figure 5), it is notable that the number of national confirmed cases almost equals that of Daegu's, indicating that most cases in South Korea (blue line) occurred in the city of Daegu (red line). During the first ten days in Daegu, the circumstances became chaotic. This brought about almost a state of collapse of the local medical services. Due to the lack of medical staff and facilities, testing all relevant people and epidemiological investigation were impossible. Some experts asserted that a nationwide lockdown should be required. Citizens started to stockpile masks and essential medicines hearing the rumour of the lockdown.

In the above period, at the forefront of the national COVID-19 response system, the Daegu city government attempted to lead the system through unprecedented, practical (efficient and effective), and properly localized approaches. In particular, the local government focused on the establishment of an extended network governance system. This helped to prepare a series of contextually modified approaches swiftly without a procedural decision-making process. Moreover, innovative approaches such as the introduction of the residential treatment centre, drive-through screening station and walk-through screening station significantly reduced the burnout of medical staff and secured a certain level of medical services.



Source: Seok et al., 2021a; revised by Author

Figure 5. Change of the number of patients in hospitals and Residential Treatment Centre

Through the above active measures, however, there were no new confirmed cases in the next 53 days, and the Golden Cross, a situation in which the number

of patients cured of COVID-19 exceeded the number of new confirmed cases, occurred. At this point, the Daegu Metropolitan City government changed the COVID-19 response system from state-led to citizen-led disease control. In detail, the citizen movement, the so-called '328 Daegu Movement', started with the Daegu Metropolitan City COVID-19 Emergency Response Centre on the 15th of March 2020. The movement aimed to prevent the resurgence of COVID-19 infection by responding to COVID-19 voluntarily for two weeks (since the movement was planned to finish on the 28th of March, the last day of the two weeks, it was named as '328 Daegu Movement') (Seok et al., 2021a, p. 193).

In the second wave (from the midst of August 2020 to the 19th of November), the confirmed cases of COVID-19 in Daegu accounted for 1.7 % of the nation. This ratio is in stark contrast to the ratio in the first wave, which was 91.14 %. Regarding the population of Daegu in 2021 (2.3 million, which accounts for 4.6% of the nation), the number of confirmed cases in Daegu was objectively low. The length of the period of the second wave was also shortened compared to that of the first wave (Jeong et al., 2021).

We can handle the pandemic in the second wave, since we focused on mass infection after the first wave. To respond to mass infection, we prepared several key policies such as promoting citizen-led disease control, conducting free anonymous COVID-19 tests regardless of symptoms and conducting tests for all vulnerable groups ((Interview with a senior officer from Social Disaster Division, Citizen Safety Office Bureau, Daegu Metropolitan City, 2022).

Based on the feedback about the first wave, the Daegu Metropolitan City government aimed to imagine a more detailed situation and prepare measures by estimating and simulating various scenarios in the second wave. The local government particularly secured more beds for severe symptom cases, introduced facility quarantine programs and established a consultant group regarding the twin-demic. Moreover, as a long-term economic support, policies and institutions were largely prepared from this period.

Finally, during the third wave of COVID-19 in South Korea from November 20, 2020, to February 18, 2021, state-led disease control became necessary due to the widespread nature of the virus across the country. Unlike the previous waves, which were concentrated in Daegu and a religious cult, the third wave affected the entire nation, making it difficult for civil servants and experts to respond efficiently. Despite the increase in confirmed cases, Daegu only accounted for 2.3% of cases in the country. The city government considered this a positive outcome and maintained their existing response policies and programs while also providing periodic medical services for vulnerable groups and establishing hospitals and residential treatment centres for infectious diseases.

IV. Discussion

Starting from the idea of a smart city, this study argues the necessity for a new definition, which illustrates the 'smartness' of a city, originating from the cumulative outcomes of experiences rather than constructed from scratch. Thus, we paid attention to 'the agile model' in explaining the evolutionary aspects of building the region's competitiveness which is backed up and accelerated by urban ICT infrastructures (Mcbride et al., 2018). This also brings about the improvement of urban resilience. Ultimately, this article aims to build a new framework that can address the smartness of a city, a mixture of the conceptual framework of a smart city, evolutionary urban resilience, and urban agility.

In the empirical case of Daegu, the city government's diverse responses to COVID-19 have revealed various characteristics. These have been conceptualized as a cycle that supports both the agility as well as the resilience of a city: (1) Design (Exploration); (2) Experiment; (3) Localization (Deployment); and (4) Feedback (Upgrade). The four phases within a cycle can be illustrated in the diagram (Figure 6) below.

First and foremost, the design (Exploration) phase aims to furnish an environmental condition to a certain level. The most important point of this phase is to establish both an offline and online governance system, which enables responding to the diverse issues regarding COVID-19 conveniently and swiftly compared to the traditional governance systems. In this context, not only smart city infrastructures, so-called ICT-based open-access software and hardware systems, but also legacies from past experience and knowledge are completely used.

Secondly, the experiment phase seeks to find a diverse unprecedented and innovated approach to respond to COVID-19 efficiently. Then, they can reproduce it, interpret the reproduced one and gain practical feedback under their unique perspectives. This leads to an increase of system reliability, removing the uncertainty of individual opinion. Moreover, open-access data encourage citizens to participate in a COVID-19 response system. For instance, a citizen made a smartphone application, which discloses information on the routes of confirmed cases over time based on open-access information on the online platform.

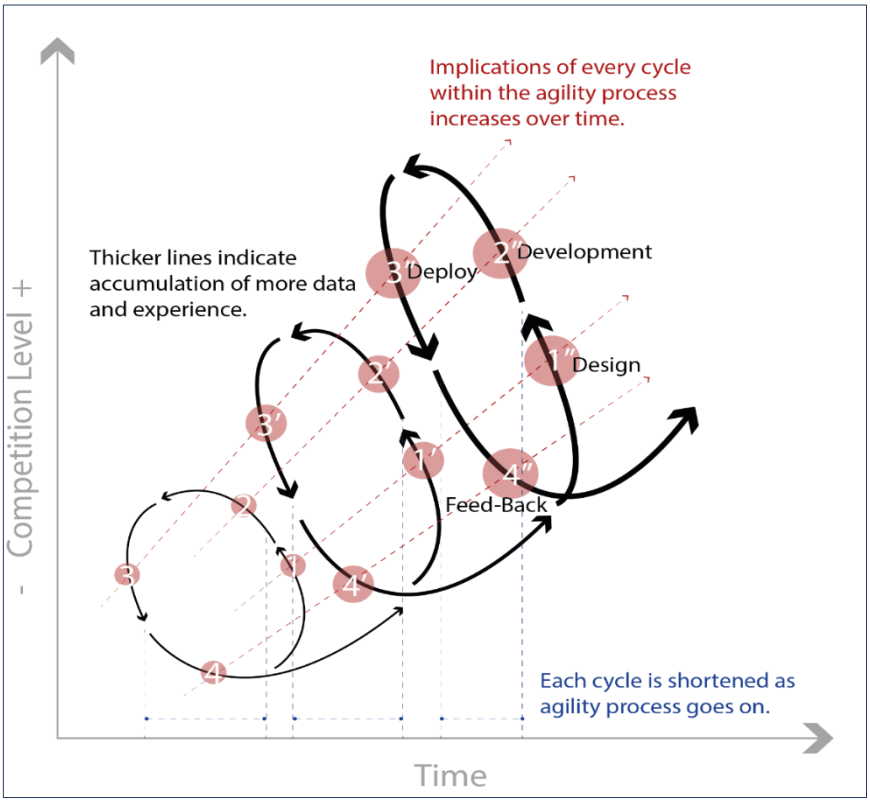


Figure 6. The concept of Agile City

Thirdly, in the deployment phase, the main aim is to localize and take the root of floating policies, institutions, and programs. In this stage, field experience is more emphasized rather than theories. For instance, the MERS outbreaks and the Daegu subway fire worked as local legacies, so the Daegu Metropolitan City government can make a decision resolutely and endeavour to persuade the central government to agree with the local government's decision. Such a process should swiftly, objectively and reliably happen.

Lastly, the feedback loop of policy decision and implementation should occur over time. The repeated testing and stabilization process of the innovative approach increases its adaptability on the whole society. Furthermore, by compressing the time and quality of feedback over time, the characteristics of the idea of an agile city will be emphasized. In Daegu, for instance, through the three waves, such a feedback process works very well, and this motivates this

article to argue that Daegu Metropolitan City can be called an agile city, with more developed and evolved urbanism compared to the idea of a smart city.

The definition of the smart city concept has become ambiguous despite its introduction in the 2000s, due to varying interpretations by civil servants, private experts, and academia. In Korea, the concept of the smart city was used as a substitute for the Ubiquitous City (U-city) as a manifestation of new urban development (Lee et al., 2008). While Korean academic literature typically measures the smartness of cities by focusing on high technology infrastructure, there has been a lack of emphasis on discourses of social innovation in the urban area (Choi et al., 2020; Lee & Chang, 2019; Myeong et al., 2020). In the empirical case of Daegu during the COVID-19 outbreaks, various characteristics and four phases within a virtuous cycle in Daegu demonstrate that the city already has had proper and new methods and can be somaticized as an 'agile city'. Consequently, this research contributes to the establishment of a new urban policy framework that prioritizes urban resilience as evidence of new evolution from the smart city concept: regarding the achievement of urban resilience as a proof of new evolution from the idea of a smart city.

V. Conclusion

One of the distinct features that makes COVID-19 unique within urban areas is its occurrence in an era of the smart city, a somewhat nebulous concept (Townsend, 2013). The idea has been pervasive not just in practice, but also academia in multiple literature domains, such as those related to governance (Mouton & Burns, 2021), innovative technology (Busch et al., 2021), and urban space (Rosol & Blue, 2022) .

Moreover, while crises caused by the pandemic disease have exposed radical vulnerabilities across urban economies from social distancing to border control, its occurrence has paradoxically enforced a momentum for innovative experimentations (Clark, 2020). The concepts regarding smart and innovation are legible in the plethora of industries, public health care and urban management (Rosol & Blue, 2022). Smart city literature so far has concentrated on demonstrating the potential enhancement of urban management issues, arguing the extent to which the city might be measured as a 'smart' city. Little is known how it actualizes 'smart' policies in the midst of unprecedented threats.

It is difficult to deny that the smart city is one of the emblematic concepts in both economic geographic and ICT technology fields. However, this research could be a timely reminder, which begins to consider the necessity of the idea of agility (as an advanced idea of resilience) over the smart city framework in the field of urban economy. In this context, the case of Daegu provides the

empirical evidence of how policy makers collect data from multi-sources, conduct the setting-up of the data-driven policies, and plan the next steps. Daegu case also demonstrates that a city's resilience emerges from smartness in controlling the pandemic and maintaining core urban functions. While there is a growing body of literature on smart city implementation, this study contributes to expanding the scope of urban resilience literature through the agile innovation model. The case also draws attention in that the openness of the confirmed cases reinforces the voluntary engagement of normal citizens. All of this is possible not just from the cumulative investment of ICT infrastructure, but also legacies from previous policy failure and diverse experiences through another pandemic disease in the past, MERS.

Although it is not the first nor the last crisis, this research argues that the difference lies in the fully adaptive applications of ICT technologies. It is notable that the speed of the policy-making cycle – from planning, implementation to feedback – has been speeded up and monitored more thoroughly based on the data-driven city platform. During the feedback, policy failures (Baker & McCann, 2018; Howlett, 2012) have been corrected more rapidly and consequently, the overall circumstance and process have evolved and developed over time. This context can be interpreted as an agile city, which represents the current urban status and the capacity of urban resilience more correctly rather than the conventional idea of a smart city. This model captures the evolutionary and cumulative development of smart cities, highlighting the importance of repetitive cycles in the evolution of smartness.

The analysis in this paper is subject to a few limitations, which could provide avenues for further research. One limitation is that it focuses on the case of Daegu, South Korea, and may not be fully generalizable to other cities across globe and their response to the COVID-19 crisis. Additionally, the study primarily focuses on the utilization of smart technologies of local state, and may not fully address other factors that contribute to a city's economic resilience during a crisis. Another limitation is that it only focuses on the initial stage of the COVID-19 crisis, and may not fully capture the long-term effects on the urban economy and the smart city's response to it. This research sought to become the background of further study, which might conduct in-depth interrogation of the characteristics of the agile city in detail and make a comparison study between the city of Daegu and the other specific cities in South Korea.

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