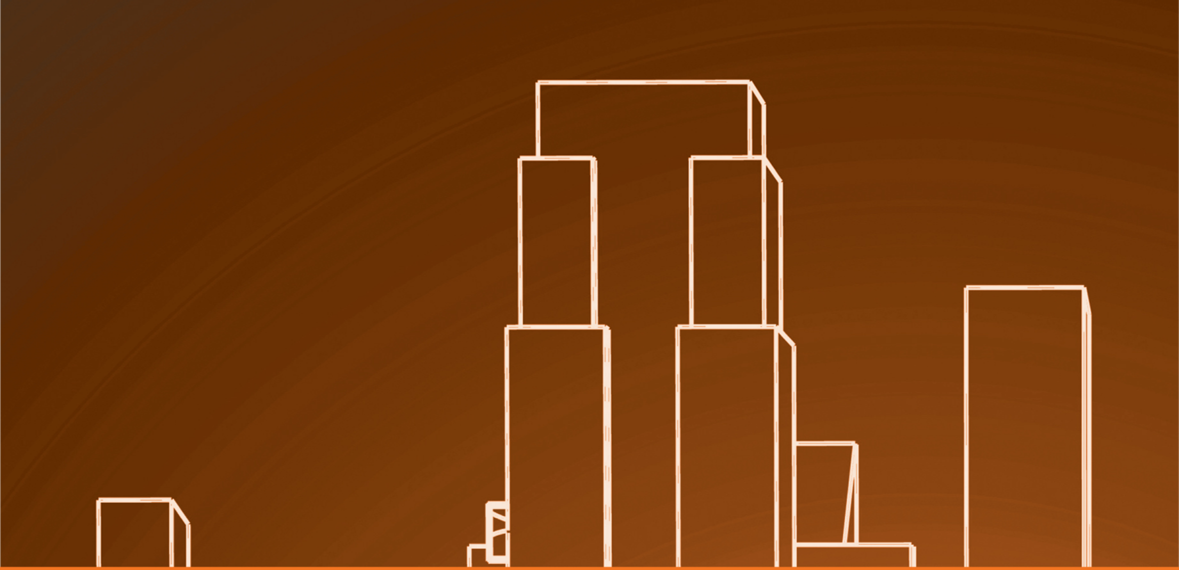

Routledge Advances in Regional Economics, Science and Policy

DESIGNING SMART AND RESILIENT CITIES FOR A POST-PANDEMIC WORLD

METROPANDEMIC REVOLUTION

Anthony Larsson and Andreas Hatzigeorgiou

ROUTLEDGE

"Crises such as pandemics can be devastating, but also of opportunities for innovation. In this book, the authors give historical examples of both and apply forward thinking to show how the COVID pandemic has shown the power of both the biotechnological revolution to tackle the challenge and offer much hope for the future response to health crises. Similarly, the digital revolution empowered effective communication from a distance and offers many opportunities for future improvements. This is an optimistic book, but firmly based on recent experiences and great technological advances. A very good read!"

Sir Richard J. Roberts, Distinguished University Professor, New England Biolabs, Massachusetts, USA, Laureate of the 1993 Nobel Laureate in Physiology or Medicine

"Anthony Larsson and Andreas Hatzigeorgiou have given us a well-written and comprehensive view of the challenges facing cities in the aftermath of a pandemic, as well as ideas about strategies they can use to move forward. It will be a valuable resource for both scholars and policymakers."

Robert E. Lucas, Professor of Economics (Emeritus), University of Chicago, Illinois, USA, Laureate of the 1995 Nobel Memorial Prize in Economic Sciences

"I am very impressed with this timely book on smart cities. So many cities are in need of regenerative marketing. Branding is not the first step. The first is to make the city better. Then communicate the new positives of the city. If I were a city mayor or manager, I would assign the chapters to my respective managers of housing, labour, sustainability – asking them to bring back a set of new ideas and recommendations for improving their sector."

Philip Kotler, Professor of Marketing (Emeritus), Kellogg School of Management, Northwestern University, Illinois, USA, Author of "Marketing Places"

"Now more than ever, the world needs smarter, healthier, more sustainable and resilient cities and metro areas. Larsson and Hatzigeorgiou provide the guidebook for making the transition to a better post-pandemic world."

Richard Florida, Professor of Business and Creativity, Rotman School of Management, University of Toronto, Canada, Author of "The Rise of the Creative Class"

"The COVID-19 pandemic had a massive negative impact medically, economically, and socially, but thus far, there's little agreement as to what 'next steps' should be. Throughout the pandemic, state, national and international organisations struggled to implement interventions at the local level with variable degrees of success. Anthony Larsson and Andreas Hatzigeorgiou, in *Designing Smart and Resilient Cities for a Post-Pandemic World: Metropandemic*

Revolution, provide a cogent, practical, stepwise approach to prepare our cities for their essential role in the next national/world crisis. Each chapter identifies a critical quality or competency that together, define a resilient city. Anyone with a leadership role or simply a strong interest in good municipal government should read their book. It will have a powerful impact on how we view our cities and our ability to advocate for creating positive change."

Francis Andrew Gaffney, Professor of Medicine (Emeritus), Vanderbilt University School of Medicine, Tennessee, USA, Astronaut, NASA (Retired), Guest Professor, Karolinska Institutet, Sweden

"*Designing Smart and Resilient Cities for a Post-Pandemic World: Metropandemic Revolution* is more than just a must-read book; it is a window into the future that leaves few stones unturned. With their unique combination of engaging storytelling and analytical precision, the authors offer an innovative, balanced and factual insight of possible future technological developments aimed at strengthening our cities' resilience and safety in a post-pandemic world."

Björn Eriksson, President of Interpol (1994–1996), Honorary Doctor of Philosophy, Linköping University, Sweden

"Those looking for an insightful account of tomorrow's digital technology and how it can be used to foster future pandemic resilience in our smart cities will find great inspiration from this comprehensive, but easily digestible guide by Larsson and Hatzigeorgiou."

Nicholas Fortugno, Video game designer and educator, Playmatics, LLC, New York City, USA

Designing Smart and Resilient Cities for a Post-Pandemic World

Are pandemics the end of cities? Or, do they present an opportunity for us to reshape cities in ways making us even more innovative, successful and sustainable? Pandemics such as COVID-19 (and comparable disruptions) have caused intense debates over the future of cities.

Through a series of investigative studies, *Designing Smart and Resilient Cities for a Post-Pandemic World: Metropandemic Revolution* seeks to critically discuss and compare different cases, innovations and approaches as to how cities can utilise nascent and future digital technology and/or new strategies in order to build stronger resilience to better tackle comparable large-scale pandemics and/or disruptions in the future.

The authors identify ten separate societal areas where future digital technology can impact resilience. These are discussed in individual chapters. Each chapter concludes with a set of proposed "action points" based on the conclusions of each respective study. These serve as solid policy recommendations of what courses of action to take, to help increase the resilience in smart cities for each designated area. Securing resilience and cohesion between each area will bring about the metropandemic revolution.

This book features a foreword by Nobel laureate Peter C. Doherty and an afterword by Professor of Urban Technologies, Carlo Ratti. It provides fresh and unique insights on smart cities and futures studies in a pandemic context, offers profound reflections on contemporary societal functions and the needs to build resilience and combines lessons learned from historical pandemics with possibilities offered by future technology.

Anthony Larsson is an author, editor and researcher. He currently serves as Research Fellow at the Stockholm Chamber of Commerce, Sweden.

Andreas Hatzigeorgiou is the CEO of the Stockholm Chamber of Commerce, Sweden, and is an affiliated researcher at the School of Architecture and the Built Environment, KTH Royal Institute of Technology.

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Designing Smart and Resilient Cities for a Post-Pandemic World

Metropandemic Revolution

Anthony Larsson and Andreas Hatzigeorgiou

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Contents

Figures

Tables

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Authors’ Note

With *Designing Smart and Resilient Cities for a Post-Pandemic World: Metropandemic Revolution*, we present a book that seeks to take a more open and exploratory approach to the question of how smart cities can be reshaped in the wake of pandemics or similar disruptions. This book is designed as a series of investigative studies that discusses and compares different cases and impending technological developments in smart cities through a series of different societal themes against a pandemic backdrop.

In this book, we seek to understand how past pandemics have affected cities. We draw upon multiple practical examples of smart cities internationally where present, nascent and future smart technology and strategies have been, and are being, developed to build resilience. While this book chiefly aims to investigate the role of digitalisation and new technology, it also examines policy strategies adopted by some city leaders in different smart cities. This book seeks to investigate the key components involved in the cities’ struggle towards securing cohesion between all of the investigated areas, and in that, building resilience, in addition to paying heed to the potential pitfalls that cities may face in their pursuit of resilience.

This book endeavours to provide an innovative, thought-provoking, enriching and controversial foray into society at large following a disruption, such as a pandemic, and how various aspects of digital technology and urban development can be used to secure successful future growth in a way that is not covered by extant literature on the market. In writing this book, we had three specific unique selling points in mind, namely:

- A book that provides a fresh and unique insight on smart cities and futures studies in a pandemic context.
- A book that instils contemplation on contemporary societal functions and the needs to build resilience important for the business climate, growth policy and human well-being.
- A book that combines lessons learned from historical pandemics with possibilities offered by new and future technology.

A note worth mentioning; technology is a dynamic construct and it is in constant transformation with infinite uses. As such, there are many emerging technologies not covered in this book and those that are covered are, by no means, guaranteed to succeed to see widespread use in the future. Furthermore, it is not the ambition of this book to provide an exhaustive coverage of all known pandemics throughout history, any and all new digital developments or the condition of all the smart cities in the entire world. Rather, this book has sought the best possible balanced and well-paced combination of high research quality with in-depth discussions for academics, practical recommendations for professionals, and availability and insight for a general public readership base in conveying the concepts discussed in this book with the embodiment of illustrative real-life examples.

The subject matter discusses a global, topical concern, and as such, we have aspired to write a book that holds international appeal to anyone who is eager to see the direction and impact that digitalisation and future technology can have on the societal recovery from pandemics and how smart cities can be built to safeguard society in the future. We believe that the subject matter is relevant to a general, international readership in addition to a wide array of professional and academic disciplines, such as business and innovation studies, futures studies, economics, political science, sociology, city planning, urban studies, informatics and philosophy. Whether the subject matter engages policymakers, journalists, academics, business representatives, think tanks, government organisations or just member from general lay public, we have placed particular emphasis on the accuracy, pacing, readability and comprehensibility of the narrative. Given the nature of the subject matter, this book will at times engage with complex concepts and ideas, and thus due consideration has been given to render these in as easily digestible, albeit factually correct manner as possible, citing the latest cutting-edge research in each respective area.

We, the authors, would like to take this opportunity to extend our deepest gratitude to Staffan Salén for his invaluable insights and intellectual support. We also wish to convey our profound thanks to our illustrator Åsa Kax, for her relentless work in assisting us in providing illustrations and procuring the necessary licences wherever applicable. We wish to express our sincerest appreciation to policy analyst Emily Nagler at the Stockholm Chamber of Commerce for her assistance, insight and support to Professor Doherty's foreword. We would like to express our gratefulness to Professor Lars Hultkrantz at Örebro University, Dr Johan P. Larsson at Robinson College, University of Cambridge and former Stockholm Chamber of Commerce employee Christopher Marton, for their much appreciated feedback. We also extend our most utmost heartfelt thanks to our editor Kristina Abbotts and editorial assistant Christiana ("Chrissy") Mandizha, along with the rest of the assisting staff at Routledge/Taylor & Francis for their help and support throughout every step in the making of this book and in the promotion of its release.

Last, but not least, we would also like to extend our special gratitude to all family, friends, supporters and colleagues at the Stockholm Chamber of Commerce and elsewhere, for their unwavering and invaluable moral support throughout this process.

On a final note, we hope that you, the reader, will have as much satisfaction in reading this book as we had in writing it. We hope the topics raised in this book will spark an interest in further studies into this subject matter. As an open access product under the Creative Commons Attribution-Non-Commercial-No Derivative (CC BY-NC-ND) licence, we invite you to spread and redistribute this book freely to any and all interested parties you may encounter.

Anthony Larsson, Ph.D, and Andreas Hatzigeorgiou, Ph.D
Stockholm, August 15, 2022

Foreword
Pandemic Lessons – What the Future Can Teach Us

Peter C. Doherty

While pandemics will invariably illustrate and expedite the power of modern molecular medicine, they also serve as a reminder of the frailty of the human condition and of our societies at large. As such, pandemics stress the urgency of our societies to secure pandemic resilience and in this, the advancement of technology is an essential component.

Pandemics have always been a threat to humanity, often defining pivotal points in our history. Ever so easily, such events fade from one's memory, turning them more abstract, in turn making it easier to trivialise the trauma in one's mind as the decades stretch on. However, as much as pandemics have defined history through tragedy, they too have preceded eras of great advancement. The Renaissance followed the Black Death, improvements were made to urban sanitation and improved the efforts to secure safe drinking water following the many cholera outbreaks, to name but a few examples. It is time for us to now start considering the aftermath of our own hardship and what we can learn from the past few years.

As this book aptly points out, COVID-19 has exposed the weak points in our urban framework. In that, cities became the hotspots for the pandemic. As bastions of trade, there is increased fiscal, ideological and physical exchange amongst inhabitants, fuelling the modern, internationalised world in which we live today. However, the pandemic has exposed the level of ease at which this exchange reaches exponential levels when it comes to infectious diseases. High-density living nourishes the viral respiratory infection that must keep moving to survive but, as will be extrapolated upon throughout this book, it does not carry the sole and full responsibility for the struggles that cities have experienced.

The issues raised around how the health and welfare of citizens should function within urban settings are of particular concern. Having a robust public healthcare system is instrumental in providing critical support to increased demands and upholding extant systems. Aside from simply reducing the spread of infection, many countries around the world mandated lockdowns in order to save their healthcare systems from total collapse. Despite the mostly political roots of the manifested problems, the transpired events should never have happened the way they did in an age of smart cities and digital technology.

Digitalisation, analytics, and transparency may be the solution to these issues, and as highlighted throughout this book, is an area with much development potential over the course of the next few years. The ability to personalise healthcare at the patient level through artificial intelligence could be a breakthrough in terms of localised well-being assessments and even research relating to more nuanced public health issues that plague cities. Of course, this calls into question a myriad of other issues surrounding privacy and access to personal data. Naturally, the pros must always outweigh the cons and there needs to be a system of checks and balances in place. Regardless, we must find ways to mitigate the global suffering brought on by pandemics, by strengthening our resilience.

The manner in which countries across the planet have come together to tackle this virus has not always been perfect, but nonetheless impressive. Vaccine development and rollout have been successful overall (albeit, at times, with a global disparity of distribution), governments are paying heed to the experts within the field, and the general populace are by and large complying with the rules and recommendations set forth by the authorities. This illustrates that we can indeed function as a global society to counter major challenges.

If anything, the pandemic has shown that mankind is not above nature. This is something our policymakers and business leaders will need to recognise in regard for future pandemics disasters and environmental problems. It is with hope that the ideas put forth here can stimulate the discussion surrounding how our lives have been changed and what we can do to make things better for our future in a post-pandemic world.

Peter C. Doherty
Professor of Immunology, Doherty Institute, University of Melbourne, Australia and St. Jude Children's Research Hospital, Tennessee, USA; Laureate of the 1996 Nobel Prize in Physiology or Medicine

Outline

Overview

1 Introduction

Pandemic Resilience in Smart Cities – The Metropandemic Revolution

1 Introduction

1.1 Past Perceptions of Future Cities

The future does not always turn out the way we expect it to. For centuries, visions for future cities have existed, propelled by a desire for improving the urban environment and transforming our ties with the urban space (Boyko, 2021). Futurists, philosophers, urban planners and many other intellectuals alike have toyed with the idea of what the future will hold, occasionally hitting the mark, and other times being egregiously off point. Oftentimes, these visions have been fuelled by either anticipation or trepidation for the new and unknown. Various representations and depictions of future cities have many times found their way into popular culture.

One of the most famous early fictional depictions of what something resembling a smart city could be like is found in the mythical depictions of Atlantis (Termanini, 2018). Interestingly, the original Platonic depictions of Atlantis in his works *Timaeus* and *Critias*, written circa 360 BC, tells a story of an affluent, but corrupt civilisation with a powerful navy that attempts to invade Athens but is repelled and the island is subsequently engulfed by the sea following an earthquake (Hackforth, 1944; Osman, 2014). The story of Atlantis does not feature significantly in Plato's original texts. However, the more popular iterations of Atlantis as a technologically advanced utopian civilisation stem in large portions from more recent Western misrepresentations of the original source material, most notably *Atlantis: The Antediluvian World*, by Ignatius L. Donnelly (1882).

Written in 1863, but published 131 years later, Jules Verne (1994) provided an early literary rendition of the future city in *Paris in the Twentieth Century*. Set in a then-futuristic 1960, he predicted technological innovations such as fax machines, high-speed railways, wind power, etc. However, Verne's futuristic Paris depicts a grim, dystopian view of civilisation, where literature and creative writing is shunned and only technological writing is encouraged, and where the government is beholden to decide what is art and what is not.

In *The Machine Stops*, E. M. Forster (1909) envisioned a future in which all cities have moved underground, and where the people live alone in small

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pod-like rooms in a honeycomb of vast, multi-layered underground cities distributed across the world. There, the people rely on a giant machine to provide for all their needs. Forster suggested that the prospect of a society where no one has to work at all is just as intolerable, in its own way, as the prospect of a world of men enslaved. The story, which raises the question of what people will do if they fail to serve a useful purpose, concludes that the lives of people will be empty and dispirited.

In *The Iron Heel*, Jack London (1908) envisioned the futuristic wonder-city of *Asgard*, constructed by society's elite (effectively robber barons known as the "oligarchy") to be admired and appreciated as well as lived in, contrasted by the thousands of proletarian residents living in utter destitution and only called upon to complete public work, such as digging canals, etc.

In *Nineteen Eighty-Four*, George Orwell (1949) tells a dystopian story set in London in the eponymous year. He described a future where the entire world has been divided up into three totalitarian communist superpowers. "Fake news" is perpetuated by the incessant revising of history books and other documents to fit the current, ever-changing, narrative and the concept of objective truth is effectively obliterated. The rule of the government is secured by constant surveillance. In every person's home hangs a large "television monitor" that carries the purpose of supervising the population at all times. Crime is controlled by surveillance. Privacy no longer exists and it is a crime to attempt to seek it. The English language and its vocabulary are under constant reduction in order to make the people as uneducated and uncritical as possible. Every sentence that is uttered must first be carefully considered, for unguarded words betray politically unorthodox thoughts, or "thoughtcrimes"; the most serious crime of all.

In *Atlas Shrugged*, Ayn Rand (1957) described a scenario in which elites would build their own clandestine city/town in the Colorado mountain valley known as "Galt's Gulch". This community had been founded as the result of a desire by the intellectual elites to escape the normative constraints and demands for conformity by the ruling bodies to instead pursue their own goals, well out of bounds from the "conventional denizens" and oppressive anti-intellectual ruling class.

James Blish (1956) anticipated in *They Shall Have Stars*, and throughout the rest of his *Cities in Flight*-series, that by the year 2018, cities would be using an anti-gravity device with gyroscopes called a "spindizzy" that would enable an entire city to fly through space.

In *Brave New World*, Aldous Huxley (1932) imagined London as a "World State city" by AD 2540, in which citizens would be engineered by means of artificial wombs along with childhood indoctrination programmes into predetermined classes/castes based on intelligence and labour. In his non-fiction follow-up, *Brave New World Revisited*, Huxley (1958) asserted that the development towards the world he had depicted was happening much more rapidly than he had anticipated, adding that overpopulation was one of the causes of this.

The topic of city (and world) overpopulation was further elaborated upon by Isaac Asimov in his 1991 non-fiction book *The March of the Millennia*, where he envisioned that earth would house a population of 75,000 billion people by the year AD 3000 (Asimov & White, 1991). Of course, the remote possibility exists that humanity has become a spacefaring people by that time, with the ability to colonise worlds in faraway places. However, should the human development be concentrated on Earth, nature will know its bounds, it will know stops, adaptation, restarts, etc. (Autino, 2012). Oftentimes "dents" in the demographic curve have been caused by catastrophes, war, famine, droughts, plagues and pandemics (Blaikie, Cannon, Davis, & Wisner, 1994; Honigsbaum, 2019).

Perhaps a more foreboding pandemic future was presented by H. G. Wells (1933) in *The Shape of Things to Come*. In this story, a prolonged recession plunges Europe into a devastating alternate World War II lasting from 1940 to 1950, with ultimately no side emerging as the victor. The world governments collapse and from 1956 to 1957, the world is plagued with a pandemic that effectively throws all of the world's cities back to medieval conditions, before gradually rebuilding society.

Whether in fiction or in reality, technology has always been one of the foremost driving forces of societal development (Bard, Söderqvist, & Larsson, 2020). It is in the cities that a vast majority of all important technological innovations have been made throughout history (Berkin, Miller, Cherny, & Gormly, 2015; Cocks & Johnson, 2021). This is further emphasised by the "ripple effects" seen in weakened cities, where cities experiencing atrophy will often carry detrimental impact on innovation in agriculture and other things countryside (Ewing, 2013; Maurrasse, 2012). As such, the well-being of cities is not merely concern for the cities themselves, but also for the rural regions as well as for the entire region and country alike. In many ways, the cities can be viewed as innovations in themselves as well. Once humanity reached a certain point in evolution, humans began understanding the immense potential of organising in dense settlements for the exchange of goods, services and ideas, for sharing and resource allocation, for market optimisation, for reducing costs for common goods such as infrastructure, and for protection. Mankind's "rooting" came with tremendous enormous evolutionary advantages and it was at this point in time cities slowly but surely began to emerge across vast geographies. Today, more than half of the world's population calls a city their home, and for that reason, the future development of cities will be of quintessential importance (Glaeser, 2011).

The amalgamation of urban development, society's technological advancement and humanity's need and desire for both is perfectly embodied in the concept of "smart cities". A smart city signifies in many ways the starting point of much of the past visions of future cities, minus the dystopian/utopian connotations to which these cities served as a backdrop. In essence, smart cities signify both the present and the future of human urban development. Ideally, smart cities would in many ways signal an advanced society, with an intelligent, civilised and prosperous population, ready to take the next leap into urban evolution. As technology has advanced and the digital transformation had become widespread, it is now possible to develop and refine metropolitan as well as other large cities in ways that were impossible only a few decades ago. Indeed, the era of smart cities is upon us.

1.2 An Introduction to Smart Cities

The need to improve the cities' capacity for competitiveness and sustainability has led city officials and decision makers to turn their attention towards finding means to secure a decent level of quality in areas such as housing, economy, culture and social and environmental conditions. This challenge has served as a worldwide impetus of making cities "smart" (Roche, Nabian, Kloeckl, & Ratt, 2012). This follows that the application of "smart cities" have come to signify a form of "seal of approval" to signify that the city is advanced and technologically developed enough to secure an improved standard of living for its denizens while utilising digital technology to successfully tackle the challenges that modern-day cities are faced with.

What then is a "smart city"? The "smart city", as a concept, has been used in its present context since the 1990s (Mustafa & Kar, 2017b). Some would argue that a smart city is a generic term that denotes the existence of digital technology mainly consisting of information and communication technologies (ICT), to develop, implement and stimulate sustainable development practices to assist in various growing urbanisation challenges (Mustafa & Kar, 2017a, 2017b). To this extent, smart cities essentially rely on an intelligent network of connected devices that transmit data using wireless technology and via cloud storage (Hashem et al., 2016; Mazza, Tarchi, & Corazza, 2017). These cloud-based applications are able to receive, process and analyse data in real-time to assist city officials, businesses and denizens to help various decision-making processes and ultimately also improving the quality of life. Denizens engage with various aspects of the smart city ecosystems whenever they use their smartphones, mobile devices, connected cars and homes. Pairing devices and data with the physical infrastructure of the city in which one lives could reduce costs and improve overall sustainability. Another advantage is that through the use of Internet of Things (IoT), communities will have the ability to improve energy distribution, streamline waste collection, reduce traffic congestion and improve air quality.

While "smart cities" have become a popular term to describe a city that uses integrated digital technology across a multitude of its facilities, assets and services, it is less clear what actually defines the term "smart city". For instance, IBM (2009, para. 8) has defined a smart city as "one that makes optimal use of all the interconnected information available today to better understand and control its operations and optimize the use of limited resources".

Conversely, Hall (2000, p. 1) offers a more outlined definition saying that a smart city is a

> city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rail/subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens.

These, along with many other definitions, serve as fairly trite and generic characterisations of the concept.

However, the fact of the matter is that there is no single universal definition of the term surrounding "smart cities" and the descriptions among those definitions of smart cities that do exist will, more often than not, vary immensely (Shamsuzzoha, Nieminen, Piya, & Rutledge, 2021). There are several reasons as to why the term "smart city" remains bereft of a clear, universal definition. One of the reasons, as explained by Dameri (2017), is the disagreement between the academic view and the empirical view. The academic view is more focussed on components, such as strategic planning, city governance structure and so forth. The empirical view, championed by companies such as IBM, Cisco etc. veer more towards emphasising technology as the chief component of a smart city.

Another disagreement concerns whether or not it should be conflated with the concept of "digital cities". It should, at this point, be clarified that for the purposes of this book, the premise is to *not* conflate the two concepts, but to treat "smart city" as its own entity. This is because a "digital city", as held by this book's premise, would rather pertain to a city's level of Internet connectivity and the infrastructure to support it, as opposed to the multitude of other associated concepts, such as artificial intelligence (AI), virtual reality (VR), Big Data and so forth (Komninos, 2006). Also, the role and interaction of human capital, along with education, social and relational capital, as well as environmental issues are generally considered important drivers of urban growth (Lombardi, Cooper, Paskaleva, & Deakin, 2009). However, in a smart city, the digital transformation of each of these sectors is also just as important. Another disagreement concerns whether "smart" refers to "knowledge", i.e. encouraging the creating, sharing and spreading of knowledge or "intelligence", i.e. encouraging the creation and spread of digital infrastructure (Ergazakis, Metaxiotis, Psarras, & Askounis, 2006; Komninos, 2006).

Of course, the contentions are many and linger far beyond the ones broached here. The fact remains that the concept of "smart cities" appears to be as clear as it is confusing in popular discourse. For the purposes of the discussion raised in this book, a "smart city" denotes a city that is digitally modernised and makes full use of various forms of electronic IoT sensors to collect data and provide services (Nanda, 2019). Examples of its use include the ability to survey and manage traffic and transportation systems, utilities, water supply networks, power plants, waste, crime detection, hospitals, information systems, schools, libraries and other community services (Han et al., 2017; McLaren & Agyeman, 2015; Mohanty, Choppali, & Kougianos, 2016; Sadik-Khan & Solomonow, 2016). At the same time, such cities also make use of "smart technology", which essentially incorporates ICT. This allows city officials to interact directly with the community as well as city infrastructure, while also being able to monitor activity in the city and how it evolves. The use of ICT can enhance quality, performance and interactivity of various urban services, while also serving to minimise costs and/or resource consumption. Moreover, it may also be used to facilitate contact between denizens and state officials (Stimmel, 2016). The use of other various "smart" concepts, such as the aforementioned AI, VR, Big Data etc. may also play integral parts to the smart city. As expressed by Su et al. (2011, p. 1029) a "smart city is the product of digital city combined with the Internet of Things".

2 Pandemics and the Case of COVID-19

There is often much terminological confusion among the meaning of (1) epidemic, (2), endemic (3), outbreak and (4) pandemic. By interpreting Grennan (2019), one may succinctly distinguish them as follows. (1) An *epidemic* refers to a disease that affects a large number of people within a given cluster i.e, a community, population or region. (2) An *endemic* is inherent to a particular population or country. (3) An *outbreak* is a number of endemic cases that has increased by far more than its expected number. Alternatively, it can be a single case that has erupted in a new area in which it does not normally occur. An outbreak may easily lead to an epidemic if it is not supressed quickly. (4) A *pandemic*, on the other hand, can be thought of as an epidemic that has spread over multiple countries or continents. Simpler yet, as "a pandemic is an epidemic with a passport" (Peters, 2021, p. 7).

Much like the aforementioned discussion on future cities and technology, the topic of pandemics is also one that has engaged many classic works throughout the centuries. For instance, Daniel Defoe (1722) provided a fictitious, but realistic, account of the 1665 bubonic plague of London in his *A Journal of the Plague Year*. Similarly, *Pale Horse, Pale Rider* by Katherine Anne Porter (1936) explores the human tragedies against the backdrop of the "Spanish flu", in which an infected woman makes a full recovery only to discover that her lover has died from the disease having nursed her back to health. Albert Camus' (1947) *The Plague* tells an absurdist, existentialist tale about a fictitious cholera-like epidemic set in the 1940s French Algerian city of Oran in which the overarching theme lies in the powerlessness of the story's characters to affect their destinies. More contemporary literary works of fiction have also explored themes of weaponised pandemics, such as Stephen King's (1978) *The Stand* and Dean Koontz's (1989) (under his nom de plume "Leigh Nichols") *The Eyes of Darkness*, which, in the updated 1989 edition of its 1981 original, centres around a bioweapon originating in the Chinese city of Wuhan (also the point of origin of the COVID-19 pandemic).

For all intents and purposes, pandemics have in no small part shaped the manner in which cities are planned and configured (Martínez & Short, 2021). In historical epidemiological contexts, one would often speak of the "urban graveyard effect", "urban death penalty" or the "urban deficit", because the death rates in medieval European cities were at such an exceedingly high level (Lynch, 2003). As will be further elaborated throughout this book, cities have throughout history developed and evolved to solve and/or manage problems concerning sanitation and health access while procuring space and opportunities for the denizens. Much like during previous plagues throughout history, cities were at the centre also during the COVID-19 pandemic. The virus spread from city to city and would claim its greatest number of causalities in the urbanised regions (Florida et al., 2020). As of May 8, 2021, it was estimated that more than 3.2 million lives had been lost due to COVID-19 (Das, Zutshi, & Janardhanan, 2022). By August 15, 2022, the World Health Organization (WHO) (2022) reported over 6.4 million cumulative deaths worldwide due to COVID-19.

To what extent dense concentrations of people living and working together have affected the spread of COVID-19 remains a contentious issue. Some have agreed that crowding is a major factor in spreading viruses, while others downplay the role of crowding and population density (Hong, Bonczak, Gupta, Thorpe, & Kontokosta, 2021; Hsu, 2020; Wong & Li, 2020). Others posit that it is strictly a matter of governance and that the rate of spread is contingent on the actions such as lockdowns etc. while others argue that the chief correlation is between density and humidity, suggesting that the climate is a key determinant to spreading the virus (Diao et al., 2021). Others speak of the "the destiny of density", which asserts that the containment of pandemics is contingent on the management of density in urban societies (Flint, 2020; Scardovi, 2021, p. 41).

While the COVID-19 pandemic imposed global quarantine on an unprecedented level, the concept of societal quarantine is not new, and has been omnipresent in many historical depictions. For instance, Giovanni Boccaccio's (1353) *Decamerone* (Eng. "The Decameron") recounts a story of ten young individuals who flee the plague-ridden Florence to a deserted villa in the countryside of Fiesole where they go into self-confined quarantine for two weeks and share a total of 100 stories with one another to pass the time. A famous example of an academic being forced to work from home was Sir Isaac Newton, who invented calculus and developed the basis for the Newtonian worldview while in quarantine in his family farm in Lincolnshire in 1665 after the University of Cambridge closed down due to the flea-borne bubonic plague (Hays, 2005).

Nevertheless, the onset of the COVID-19 pandemic during spring 2020 left the world in turmoil. Beyond the human tragedies, few could ever imagine the far-reaching and profoundly disastrous effects it would bring on the world economy. The International Labour Organization (ILO) estimated that almost 25 million jobs globally were at risk due to the pandemic (ILO, 2020). It is no understatement that the pandemic crash was indeed extreme. Following the first year of COVID-19, the global overall fiscal gross domestic product (GDP) for 2020 was nearly −3.4%, markedly lower than the 2.6% for 2019 (World Bank, 2022). It should also be emphasised that there was a vast disparity in numbers of how severely the pandemic affected the GDP depending on the countries' economies.[1] For instance, the "advanced economies" reported a government fiscal balance of −10.2% of the GDP, while the figure for "emerging market economies" was −9.6%, with the "low-income developing countries" presenting a figure at −5.2% (International Monetary Fund, 2021). Additionally, some 114 million jobs were lost internationally during 2020, with an additional shortcoming of 30 million prospective new job opportunities due to the pandemic, bringing the total number up to 144 million jobs (International Labour Organization, 2021). While figures gradually improve over the years as the rate of global vaccination increases, the pandemic will leave a dent in the global labour market for many years to come (Pallapa, 2022).

During the onset of the COVID-19 pandemic, many leading politicians expressed themselves in exceptionally strong and emotional terms. For instance, Paolo Gentiloni, the European Commissioner for Economy, described the situation by saying: "Europe is experiencing an economic shock without precedent since the Great Depression" (European Commission, 2020, para. 5). Secretary-General of the United Nations Antonio Guterres and the then-German Chancellor Angela Merkel went even further and compared the magnitude of the COVID-19 eruption and its socioeconomic ramifications to World War II rather than previous modern-era financial crises (Nulman, 2022). Hyperboles and recency bias[2] notwithstanding, it is true that digital technology facilitated lockdowns and made them feasible (Kenney & Zysman, 2020). Moreover, some would argue that technology has been paramount in averting a complete collapse of the economic system (Ionescu, Iordache, & Țițan, 2021).

As "social distancing" became a buzzword in our vernacular, the use of digital services increased considerably as an increasing number of people around the world turned towards working remotely (De', Pandey, & Pal, 2020). However, society, as we know it, would, for all intents and purposes in the mind's eye of the many, be known as the time "pre-COVID-19" and "post-COVID-19". The ensuing debate will therefore focus not so much on rebuilding what once was (since it has proven largely ineffectual to combat pandemics such as this one), but rather on what type of new society that would be needed to counteract the same events and processes from repeating should another pandemic of this scale surface again.

Today, 55% of the world's population reside in urban areas, and this number is anticipated to increase to 68% by the year 2050 (United Nations, 2018). This is, in part, due to urbanisation, i.e. the gradual shift in residence of the human population from rural to urban areas, but also due to the overall growth of the world's population as well, which combined, could add another 2.5 billion people to urban areas by 2050. According to the United Nations, roughly 90% of this increase is occurring in Asia and Africa (United Nations, 2012, 2018). The cause of urbanisation is a contentious subject. Some will argue that consumers and their pursuit for attractive places to live are the main drivers of urbanisation (Glaeser, Kolko, & Saiz, 2001). Others will argue that urbanisation is mainly driven by economic factors such as industrial growth, and as the economy expands, so does urbanisation (Gong et al., 2012).

Notwithstanding, historically, cities have managed to withstand war, terror, famine, poverty, catastrophes, pandemics and many other types of force majeure. In many cases, such devastating events have been the catalyst for reform and innovation that have served to advance the cities rather than destroy them (Thompson, 2020). For instance, the 1755 Lisbon earthquake claimed somewhere between 10,000 and 30,000 lives, making it one of the deadliest earthquakes in recorded history, while costing Portugal between 32% and 48% of its GDP (Molesky, 2015; Pereira, 2009). This earthquake, in turn, was one of the main catalysts behind the development of seismology (Shrady, 2008). The British cholera epidemic in 1832 brought the life expectancy to roughly 26 years of age in communities with more than 100,000 individuals (Thompson, 2020). This epidemic would finally help pave the way towards improved sanitation facilities and a revolutionised attitude towards hygiene and its linkage towards the spread of diseases (Morley, 2007).

The city of New York suffered three great fires (1776, 1835 and 1845) that each rendered extensive damage to the city. During the first fire, between 10% and 25% of all the buildings in the city were destroyed, with massive looting ensuing in the unaffected parts (Carp, 2006). The second fire would claim an estimated US$20 million of property damage (≈ US$606 million real price in 2020) (McNamara, 2019; MeasuringWorth, 2022). The third fire would claim property damages of approximately US$10 million (≈ US$353 million real price in 2020) (MeasuringWorth, 2022; Rivers, 2016). Each of these fires would help mobilise the citizens. For instance, the 1776 fire, popularly referred to as "the Great Fire of New York", was in great part stopped by efforts from the citizenry (Carp, 2006). This was also the case for the other two subsequent fires.

After the 1835 fire, improved buildings were built during the recovery which entailed that wooden buildings were replaced by larger stone and brick constructions that were less flammable. The fire also prompted the construction of a new municipal water supply, such as the Old Croton Aqueduct which would give fire-fighters enough water supply even during wintertime, along with overall improved fire services (Cannon, 2009; Thompson, 2020). By the same token, the 1845 fire validated the importance of building codes that restricted wood-frame constructions. Notwithstanding, the fire also prompted a more proactive stance in regard to fire prevention and firefighting (Golway, 2002). In comparison, COVID-19 was, by some, referred to as "the great accelerator" given the boost to the digital transformation in businesses and society at large that followed the pandemic (Amankwah-Amoah, Khan, Wood, & Knight, 2021, p. 608). To this end, cities have always had ways of responding to disasters, while always seeking to improve and better themselves based on the uncovered shortcomings.

Against this backdrop, different cities around the world adopted different strategies in handling the pandemic (Muro et al., 2020). Some were adopted on a national level, some were adopted on a federal/provincial level, while others were adopted on a regional or local level. Some cities let scientists take the lead, whereas others relied on politicians to find the correct coping strategy against COVID-19 (Duhigg, 2020). Different cities were able to handle different aspects of the pandemic eruption with more favourable results in certain areas than others. Even if identifying the given strategies in those areas may not provide a panacea for other cities for future pandemics, it can open up for a much-needed debate among politicians, academics, policymakers and lawmakers around the world. To this extent, smart cities will play an instrumental role in future-proofing cities for similar pandemics (Allam & Jones, 2020; Costa & Peixoto, 2020; Sonn, Kang, & Choi, 2020).

3 Smart City Index

As previously mentioned, no clear ubiquitous definition of "smart city" exists at present. There are many different indices abound that purport to measure different aspects of smart cities (Nasrawi, Adams, & El-Zaart, 2015; Patrão, Moura, & de Almeida, 2020). Many of these are primarily centred on the ability to engage ICT and the application of it for economic and social benefit, while also assessing to what extent the authorities are using ICTs to deliver public e-government services to the city's denizens. Other indices focus more on the ability to manage change as well as on the environmental performances and policies (Nasrawi et al., 2015).

Ideally, there would be a multidimensional methodological model that measured the performance of a smart city from all angles while being observant of the city's context. In October 2021, more than a year into the pandemic, the Institute for Management Development, in collaboration with Singapore University for Technology and Design (SUTD) released the 2021 "IMD-SUTD Smart City Index (SCI)", with key findings on how technology has played a role in the COVID-19 era in a way that is likely to remain (IMD, 2021). The 2021 SCI edition was developed by surveying 120 residents in each city across 118 cities worldwide in July 2021.

This index seeks to assess the perceptions of city denizens on issues related to structures and technology applications available to them in their respective city. In SCI, there are two "pillars" for which perceptions from residents are solicited, namely the "Structures" pillar and the "Technology" pillar. The former refers to the existing infrastructure of the cities, while the latter describes the technological provisions and services that are available to the denizens. Each of the two pillars is evaluated over five key areas, namely: health and safety, mobility, activities, opportunities and governance. The cities are distributed into four groups based on the UN Human Development

Index (HDI) score of the economy to which they belong. Within each HDI group, cities are assigned a "rating scale" (ranging from AAA to D) based on the perceptions-score of a given city compared to the scores of all other cities within the same group. For instance:

For group 1 (highest HDI quartile), scale AAA–AA–A–BBB–BB
For group 2 (second HDI quartile), scale A–BBB–BB–B–CCC
For group 3 (third HDI quartile), scale BB–B–CCC–CC–C
For group 4 (lowest HDI quartile), scale CCC–CC–C–D

Rankings are then presented in two formats:

- an overall ranking (1 to 118)
- a rating for each pillar and overall

As per the SCI, the only city to receive the highest AAA "Smart City Ranking" in 2021 was Singapore, which had also claimed the no. 1 spot in 2020 and 2019 respectively (IMD, 2019, 2020, 2021). This was followed by Zurich, Switzerland, and Oslo, Norway, both holding "AA" ranking in 2021. The three lowest ranked cities were Bogota, Colombia (position 116); Sao Paulo, Brazil (position 117); and Rio de Janeiro (position 118). Each of these received a 2021 rank of "D". Looking at priorities and attitudes trending in the three highest ranking cities, we can discern the following pattern.

From a list of 15 indicators, survey respondents in each of the smart cities were asked to select 5 that they perceived as the most urgent for their city. As seen in Table 1.1, the higher the percentage of responses per area, the greater the cities' priority ought to be (IMD, 2020, 2021).

The SCI also measured the denizen's attitudes to consequences brought forth by digital technology in smart cities. Specifically, the index looked at the responses to three key privacy aspects (willingness to concede personal data, comfort vis-à-vis face recognition, and whether online information has increased trust in authorities) and the percentage of day-to-day transactions that are non-cash. The percentages of those agreeing with the listed statements are illustrated in Table 1.2 (IMD, 2020, 2021).

These results indicate that residents in highly developed smart cities value transparency, convenience and safety, while they are prepared to compromise with their integrity and privacy to a much greater extent, while also being more susceptible to obeying authorities on account of the perceived transparency and increased trust. In return, the denizens expect the authorities to provide them with adequate housing and healthcare. It should be noted that these responses were given during the full-blown eruption of the COVID-19 pandemic. While the full extent and duration of the pandemic was unknown to the respondents at the time when the survey was conducted, the results give a quintessential insight into the implications of what a smart city is expected to do for its citizens during the time of a pandemic.

Table 1.1 The most important indicators according to the denizens of each respective city in the global top-3 ranked smart cities, as per 2021 IMD-SUTD Smart City Index (SCI) compared to the 2020 figures (IMD, 2020, 2021). **Bold** text indicates highest ranked area in each respective city, while text in italics highlight the lowest ranked area.

Priority area	*Rank: 1: Singapore (AAA)*		*Rank: 2: Zurich (AA)*		*Rank: 3: Oslo (AA)*	
	2021	*2020*	*2021*	*2020*	*2021*	*2020*
Affordable housing	**67.5%**	**64.2%**	**74.0%**	**75.0%**	**69.6%**	**67.2%**
Air pollution	18.8%	18.0%	37.1%	34.4%	27.4%	27.1%
Basic amenities	21.2%	23.4%	14.8%	14.3%	19.9%	20.8%
Citizen engagement	32.9%	30.3%	12.5%	13.9%	18.5%	17.4%
Corruption	17.3%	18.9%	12.8%	15.2%	19.2%	17.4%
Fulfilling employment	51.4%	51.2%	26.2%	25.0%	21.0%	27.1%
Green spaces	17.4%	17.6%	28.0%	31.6%	17.6%	19.9%
Health services	36.2%	40.0%	11.3%	12.1%	33.4%	27.6%
Public transport	28.7%	36.1%	22.0%	17.6%	34.7%	33.5%
Recycling	33.1%	40.0%	26.2%	27.5%	16.9%	23.7%
Road congestion	25.3%	32.8%	64.0%	63.5%	30.5%	29.2%
School education	17.6%	18.9%	10.2%	10.2%	25.0%	26.7%
Security	23.6%	26.2%	28.4%	32.0%	36.4%	40.3%
Social mobility	26.1%	25.4%	16.9%	20.5%	30.9%	31.4%
Unemployment	51.1%	43.4%	32.7%	29.1%	35.1%	32.2%

Table 1.2 Attitudes towards digital impact according to the denizens of each respective city in the Global top-3 ranked smart cities, as per 2021 IMD-SUTD Smart City Index (SCI) compared to the 2020 figures (IMD, 2020, 2021). Figures indicated percentage of respondents agreeing with the statement.

Question: Do you agree with the following statement?	*Rank: 1: Singapore (AAA)*		*Rank: 2: Zurich (AA)*		*Rank: 3: Oslo (AA)*	
	2021	*2020*	*2021*	*2020*	*2021*	*2020*
You are willing to concede personal data in order to improve traffic congestion.	67.3%	65.6%	69.4%	66.4%	62.1%	58.9%
You are comfortable with face recognition technologies to lower crime.	73.0%	71.3%	59.9%	59.8%	65.3%	60.6%
You feel the availability of online information has increased your trust in authorities.	75.3%	72.5%	68.1%	65.2%	69.8%	68.6%
The proportion of your day-to-day payment transactions that are non-cash.	67.9%	71.0%	73.4%	72.8%	84.2%	84.7%

While the cashless society can be anticipated to continue evolving in smart cities, irrespective of pandemic eruptions, the prioritisation of healthcare seems, understandably, even more accentuated at this given time. The calls for affordable housing, however, would rather be a response to the high cost of living in high-ranking smart cities. Also, environmental issues have seemingly taken a backseat during the pandemic as these concerns are favoured by less than a third of the population in each respective city. Interestingly, while the denizens show trusting attitudes towards authorities, they also rank dealing with corruption and citizen engagement among the least important priorities during times of pandemics. While the social contract is seemingly strong in these cities, this may be cause for concern down the road, as it indicates complacency on the side of the residents.

Common for the three highest ranked smart cities around the world was that the majority of denizens tended to prioritise issues relating to "affordable housing". When it comes to the least prioritised areas, there is greater diversity between the cities. Singapore prioritised "corruption" the least, while "school education" received the lowest propriety score in Zurich. The Oslo residents, on the other hand, prioritised "recycling" the least. Singapore and Oslo had changed their least prioritised area from 2020, though the shifts had been in fairly small numbers from one year to the next.

Furthermore, a majority of denizens in the highest ranked smart cities were prepared to concede personal data and privacy for the benefit of receiving better traffic flows. The propensity to give up personal data had increased a year into the pandemic as opposed to when COVID-19 had just broken out. There was an overall strong majority support for face recognition technology with the stated purpose of combating crime. There was an increase overall across all cities in trusting this technology compared to the beginning of the pandemic. Likewise, a majority would feel that their trust in authorities increased along with the transparency of information, a number that saw an increase in all three cities. Finally, it would appear that decidedly few denizens were still utilising cash on frequent basis as a preferred means of payment.

4 Ten Essential Areas for Future City Development

As illustrated above, one of the major commonalities, the populace in advanced smart cities appear to have, is the open attitudes and low levels of resistance towards the widespread use and application of digital technology. When investigating the overall prospects for supportability of a city, the ten following areas are of particular interest to consider (Hjalmarson & Lochner, 2012; IVA, 2017; Stockholm Chamber of Commerce, 2019; Strategic Policy Forum on Digital Entrepreneurship, 2016):

> (1) Attractiveness; (2) Labour; (3) Housing; (4) Infrastructure and Travel; (5) Welfare and Healthcare; (6) Global Hubs; (7) Digitalisation; (8) Safety and Security; (9) Sustainability; and (10) Cohesion.

Attractiveness: A city must be perceived as an attractive place to inhabit and/or visit in order to grow. Without a population, a city will wilt and die. The challenge for a post-pandemic city is to provide a higher quality of life, in order to be able to attract people and make them feel that the city is possibly an even better place to live than before the pandemic.

Labour: There must be plenty of job opportunities to sustain a growing population, or people will likely move to where the opportunities are. With all the international layoffs, the pandemic cities will need to find ways of discerning which businesses can be kept operational (and how), and what types of businesses can be automated in order to keep the risk of virus spread down. Also, there needs to be a plan in order to ensure that the workers, whose labour has been substituted, will find opportunities to reskill, while also facilitating the growth of new job opportunities while sustaining the ones that are already extant.

Housing: In order for a city to grow, there must be enough homes for people to live in, and a pricing level that consumers are willing to pay. A challenge for the post-pandemic cities is to find a way that can facilitate this market in a world that is seeing an increased unemployment and a lower propensity for consumers to apply for mortgages.

Infrastructure and Travel: A successful city must have the infrastructure to support travel in order to assist an expanding population as well as providing the means of transportation for people. This includes ensuring that there is an adequate network of roads, public transport and other means of infrastructure available that upholds the city's capability to facilitate travel, both between cities and within.

Welfare and Healthcare: Perhaps the most pressing lesson the COVID-19 pandemic taught us is how vulnerable the welfare and healthcare systems are. For this reason, a successful city must have the readiness and supplies to handle not only a pandemic, but also societal lockdowns and isolation, where one may not always rely upon a steady delivery of imported supplies.

Global Hubs: In order for a city to be not only an active voice in the international community but to also position itself in a leading role in any given area, there must be global hubs. A global hub will allow for intentional collaboration and information sharing, which will be essential in order to build up capital in terms of both knowledge and finance during and following a pandemic. However, lockdowns are anathema to many businesses.

Digitalisation: A modern city will need to have an optimised digital infrastructure in order to function optimally. The social distancing brought on by the pandemic illustrated, in no uncertain terms, the need of digitalisation in our society, and it is essential that post-pandemic cities ensure that their digital infrastructure and services are robust and encompassing enough to sustain another possible eruption.

Safety and Security: Citizens who do not feel safe in a city will never feel content. In the days of old, societies would often build city walls to fortify the cities against outside aggressors, while also providing the denizens with an additional psychological sense of protection. However, protecting cities against an invisible, microscopic enemy requires a different approach altogether. Following a pandemic, it is essential to ensure that all institutions ensuring safety and security are fully operational. This does not only entail the law enforcing intuitions, but any and all institutions that seek to provide citizens with a sense of physical and social security.

Sustainability: A city recovering from a pandemic must position itself being sustainable in the sense that it seeks to optimise the use of its available resources and ensure that waste is kept to an absolute minimum. This applies to environment as well as the economy of the city since a city that is marred by waste cannot operate a peak performance.

Cohesion: A successful city must find the attributes that consolidate its identity and keep its population together. Securing a city-identity among the population is essential not only to secure loyalty and devotion but also to generate a keen interest among the citizens to work for the betterment of the city.

5 Building Resilience

The aforementioned areas are quintessential for post-pandemic development in order to make a city thrive. That is to say, in many ways, these areas constitute the cornerstones of a modernised, smart city. In order to make a city grow and become truly successful, it is therefore essential to ensure success in all of the aforementioned areas.

What then, more precisely, is "city growth"? Jane Jacobs (1969) argued much in terms of a city's local economy, i.e. the presence of resources, import/export and so on. Since then, the term "city growth" has taken on a broader meaning and can be thought of as a concept that seeks to create more

> efficient economic systems, greater economic growth; more efficient industries; create new jobs; a better business climate; a more inclusive labour market; more efficient and environmentally friendly transport; safer street environments; reduced energy consumption; better healthcare; competitive education; better integration; more democratic and transparent decision-making processes; better external communication; and more efficient analysis tools to design more sustainable city environments.
>
> (IVA, 2017, p. 31)

However, city growth may only occur if a society is thriving and doing well for itself. While it is true that many cities throughout history have undergone a form of renaissance with additional city growth during the post-pandemic stages, pandemics in and of themselves have stymieing effect (Keith, 2012; S. Porter, 2008). There are five main arguments to why securing pandemic resilience is of the utmost importance for future smart cities (Sadler, 2022). (1) A city that has secured resilience will help prevent a wider distribution in the event of resurgence of the disease. (2) Economic depression will either be avoided or heavily mitigated. (3) Frontline workers will not be put in harm's way. (4) The societal recovery process may initialise long before a vaccine is fully developed and deployed. (5) The fraying social fabric of extensive isolation will be averted (Allen et al., 2020; Sadler, 2022). Implementing necessary planning practices will be essential in order to ensure future pandemic resilience (Akter, Hakim, & Rahman, 2021).

Rolling out vaccination programmes is indeed in many respects, a determining factor in how quickly a society can recover from a pandemic (Khan, Dabla-Norris, Lima, & Sollaci, 2021). Nevertheless, a lesson learned from COVID-19 is that when new and unknown viruses strike, developing new vaccines may be a tricky affair. First of all, there were a multitude of different types of COVID-19 vaccines rolled out, and some countries, like China and Russia, would develop their own vaccines (Chrystal, 2021). The COVID-19 vaccines did not undergo the same level of lengthy testing as similar vaccines normally would (Sharma, Sultan, Ding, & Triggle, 2020). While it was possible to accelerate the development of the vaccine due to its similarities to viruses with respiratory symptoms, there were initially uncertainties in regard to the level of effectiveness depending on the vaccine, and for how long the vaccine would remain effective without the need of a "booster shot" (Li et al., 2020; Rzymski et al., 2021; Troiano & Nardi, 2021). There was also a matter of reported side effects (Menni et al., 2021). Vaccines will continue to play a determining role in combating any form of virus, both extant and future varieties (Chakraborty & Shaw, 2020; Khan et al., 2021). Nevertheless, digital technology proffers an advantage inasmuch that it can help keep the societal effects of the pandemics at bay while also strengthening the overall pandemic resilience of the cities. Given their integration of advanced digital technology, smart cities have an advantage in this regard. Thus, a salient issue in this regard is how digital technology and policies can contribute towards achieving resilience in a post-pandemic society.

This book will endeavour to explore how some of the nascent and future developments in the aforementioned ten areas and how these can be integrated by means of future digital technology in order to build urban resilience against pandemics, but, in this also, other against modes of large-scale disruptions on society e.g. epidemics (the less widely distributed forms of diseases), natural disasters, environmental crises, energy crises etc. Admittedly, "future" is indeed an elusive, if not arbitrary, term but, if conceptualising a timeframe, the technologies and implementations discussed in this book, could be expected to be rolled out within the next 5–50 years and beyond (assuming, of course, that they get fully developed and are successfully completed). While it is understandable to think of predictions of future technology as mere science fiction, one needs to consider that the technologies outlined in this book exist in some capacity, either already now at a burgeoning level, or at a conceptual and/or theoretical stage. Some may come to fruition, other may not, and others may do so at some level but in a revamped or reimagined manner. Some developments may happen sooner, while other may happen a long time from now. It is the *metropandemic revolution*.

6 Chapter Overview

6.1 Structure

The aim of this book is to present, investigate and analyse the societal areas in which the metropandemic revolution seeks to build and secure resilience through the interconnectivity of the discussed themes, i.e. *attractiveness*; *labour*; *housing*; *infrastructure and travel*; *welfare and healthcare*; *global hubs*; *digitalisation*; *safety and security*; *sustainability* and finally, how *cohesion* keeps all of these areas connected. These areas are presented in their own respective chapter. These chapters are structured into three separate categories. The first category, *Appeal*, discusses factors relating to how a city can secure its overall appeal and act as a magnet for existing and potential denizens, and what expectations there are to be had following a pandemic. The second category, *Facilities*, discusses how a city can ensure the availability of various amenities and resources needed to make a city thrive financially, socially and health-wise. The third and final category, *Durability*, discusses the factors that bind a society together in a robust and unwavering manner. Together, these categories parts will explore the mechanisms involved in facilitating the metropandemic revolution while also extrapolating upon real cases of various cities that have made practical implementations of new digital technology. Each chapter concludes with a series of proposed actions based on the findings discussed throughout the chapters. These action points are directed to decision makers, policymakers and others in authority who could hold sway over the future development in each respective area, but they also serve as key points to summarise the findings in each chapter as well.

6.2 Chapter Outline

6.2.1 Introduction

Chapter 1 – Introduction – Pandemic Resilience in Smart Cities: The Metropandemic Revolution

What are the challenges that lie ahead of introducing new technology to smart cities? This chapter explains some of the past perceptions of future cities and the concepts and notions behind "smart cities", as well as the impact of pandemics and more notably the case of COVID-19. The chapter discusses future digital technology and how smart cities have the potential to build pandemic resilience through the interconnectivity of ten societal themes covered in this book: *attractiveness*; *labour*; *housing*; *infrastructure and travel*; *welfare and healthcare*; *global hubs*; *digitalisation*; *safety and security*; *sustainability* and finally, how *cohesion* keeps all of these areas connected. The synthesis of which is known as the "metropandemic revolution". The chapter concludes by presenting the structure of this book as well as an outline of the included chapters.

7 Part I

7.1 Appeal

Chapter 2 – Attractiveness – How to Make a Smart City Revitalise Its Charm during and after a Pandemic

The attractiveness of a city is determined largely by its physical location and its surroundings, as well as by its level of culture and its political and societal maturity (Ernst & Young, 2013; Kourtit, Nijkamp, & Wahlström, 2021). This chapter discusses how city branding and the adoption of an attraction-oriented strategy can help achieve attractiveness. The importance of housing and job locations are discussed as important variables in increasing a city's level of attractiveness as well as how smart cities can help foster an open democratic atmosphere by increasing the level of transparency.

Chapter 3 – Labour – The Smart City and Pre- and Post-Pandemic Job Opportunities

It is known that there is a positive correlation on the migration to cities and the labour market along and the available amenities that foster the prospects of individuals finding work in the city (Buch, Hamann, Niebuhr, & Rossen, 2013). This chapter explores how a smart city may improve the available job-finding amenities as well as the type of jobs that can be expected to be most sought-after in a modern, smart city, and how the labour market can prepare itself and keep itself operational even during pandemics.

Chapter 4 – Housing – Past and Future Living

Smart cities have far-reaching implications for the housing market inasmuch that they also influence housing in traditional, non-smart cities to also adopt a "smarter" design. Chiefly, this manifests itself in four different ways. (1) "Automatic" rental housing market; (2) innovative digital platforms used also in the traditional housing market; (3) innovative policies and housing models; and (4) the ability to forecast demand on the housing market. Together, all of these factors form what is known as the "smart housing concept" (Tomal, 2020). This chapter seeks to explore how the future housing market in smart cities can be built to increase functionality and safety in times of pandemics.

8 Part II

8.1 Facilities

Chapter 5 – Infrastructure and Travel – Travelling Safe in the Future

The supportive infrastructure for travelling in smart cities in the future will rely heavily on "smart transportation systems". This includes the way our roads and supportive systems are designed. In the interest of ensuring adequate social distancing, a priority will be to try to reduce the amount of congestion and clusters of people forming both on the roads and in places such as parking lots etc. public transport will need to find ways in order to make the travel as "contact free" as possible in the interest of reducing the spread of germs. This means reducing the number of contact points in which physical contact is required from a person and an object, such as the purchase and validation of tickets etc. Special attention will be given to travel between cities (inter-city travel) as well as travel within cities (intra-city travel). For inter-city travel, there are many future developments and for domestic travel, it is likely that there will be a choice between travelling with high-speed rail (HSR) trains or with electric aircraft. The latter will have environmental and financial advantages whereas the HSR will have the option for transporting greater volumes of passengers. For intra-city travel, there are many existing and nascent modes of transportations that are expected to expand in the coming years, such as micromobility (e-bikes, e-scooters etc.). Hence, this chapter seeks to investigate the forms in which transportation of people and goods can be done in an efficient manner during and following a pandemic.

Chapter 6 – Welfare and Healthcare – The View on Health and Wellness in the Future

Smart cities are transforming the nature of welfare and healthcare in the sense that they recognise the possibility to connect the increasing abundance of health-related data, along with health and human service integration. That is to say, in a smart city, denizens have the ability to engage with smart services specifically designed to improve their health. Technologies such as AI, smart apps and smart cameras, in addition to innovative strategies and design, are but a few examples in which smart cities can address healthcare problems. To this end, smart cities can utilise sensors in order to analyse parameters such as temperature, pollution, humidity and power grid status etc. These are values that may be used as predictors to assess the health conditions of the city's denizens at any given time (Burton, 2020; Pérez-Roman, Alvarado, & Barrett, 2020). This chapter seeks to explore what values are important to handle a pandemic and how the healthcare services in a smart city can be designed to tend to the need of its denizens during a pandemic eruption.

Chapter 7 – Global Hubs – Setting Up and Sustaining International Businesses in Smart Cities in Times of Pandemics

A "global hub" can best be described as a region that provides a focal point for activities that carry global influence. Oftentimes, smart cities are perceived as global hubs in and of themselves in the sense that they provide a space of innovation that is irrespective of its physical location. However, this is not necessarily true, since the existence of a smart city does not by default entail an influx of new denizens, businesses and investments (Angelidou & Mora, 2019; Cugurullo, 2013; Datta, 2015; Komninos, 2015). This chapter seeks to explain how the characteristics of a global hub can manifest itself in times of a global pandemic, its significance to the cities and what possible strategies business enterprises can undertake to establish themselves in a smart city times of a pandemic.

9 Part III

9.1 Durability

Chapter 8 – Digitalisation – Optimising a Pandemic and Post-Pandemic Smart City

An advanced digital infrastructure and the existence of extensive digital services is a prerequisite for a smart city. Examples of digitalised amenities in a smart city include smart homes (for entertainment, security, childcare, electrical and heating), e-healthcare and smart mobility (Gray & Rumpe, 2015). Digitalisation has profound impact on everything ranging from personal relationships (facilitated through social media), to other kinds of relationships such as how denizens interact with the authorities through electronic services etc. (Gassmann, Böhm, & Palmié, 2019; Gray & Rumpe, 2015). This chapter looks at the different models of digitalisation, its pitfalls and how they can be strengthened during the onset of a pandemic.

Chapter 9 – Safety and Security – Identifying and Addressing Crime in a Pandemic Smart City

The topic of safety and security in smart cities is particularly salient since smart cities are by design vulnerable to hacker attacks as well as the potential cynical use of personal data by the authorities. Above and beyond that, there is also a matter of more "conventional" safety and security concerns, such as crime, occupational safety and health issues etc. The political leadership in a smart city must thus ensure that they apply sound risk management and digital security best practices to their own operations. They must also ensure the application of robust cyber-security and privacy practices by all participants in the smart city ecosystem. This also applies to non-governmental providers of essential services. The political leadership must also align digital security efforts with more fundamental objectives seeking to consolidate trust, security and safety in the smart city (Doku & Rawat, 2019; Kuehn & McConnell, 2018; Lacinák & Ristvej, 2017). This chapter will explore the ramifications that a pandemic has on safety and security factors in a smart city and what actions can be taken to secure that essential protocols are upheld.

Chapter 10 – Sustainability – Ensuring Urban Sustainability for Smart Cities during and after Pandemics

As the world population increases to grow and natural resources are becoming gradually scarcer, the calls are made for sustainability to become an integral part of modern technology. However, the concept of sustainability has grown to a wider concept than merely encompassing the conservation of natural resources. Nowadays, sustainability also covers a wide spectrum of different challenges, such as urban growth, transportation, carbon footprints and work–life balance (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017; Batagan, 2011; Iqbal, 2018). This chapter explores how a smart city can maximise sustainability for its denizens and how it can continue doing so even under a raging pandemic.

10 Conclusion

Chapter 11 – Cohesion – The Metropandemic Revolution and Beyond

A cohesion city is one in which the denizens aspire to help empower those within their communities. A cohesive society is unified inasmuch that they acknowledge what can be achieved if they are able to freely express themselves and their wishes (Oke, Aigbavboa, & Cane, 2018). Digital technology has the potential to achieve several benefits for social cohesion (Miklian & Hoelscher, 2017; Thapa, Sein, & Sæbø, 2012). That is to say, new technologies can help increase governance capacity and also help facilitate accountability, while also building grassroots networks and mobilisation (Castells, 2007). There are also potential benefits in assisting public policy (Stough & McBride, 2014). Moreover, cohesion through digital technology may also help foster a bottom-up approach towards securing democratic governance. Specifically, digital media adoption through e.g. smart phones, may escalate the civic engagement in politics while simultaneously supporting a more accountable form of governance (Andersen, 2009; Breuer & Welp, 2014; Welp & Wheatley, 2012). This chapter looks at how cohesion in a smart city may be affected in the light of an ongoing pandemic, and what measures the city can take to ensure that the sense of cohesion is not undermined.

Notes

1 Please refer to the International Monetary Fund's (2018, pp. 45–51) *Fiscal Monitor, October 2018: Managing Public Wealth* for a more extensive explanation of the categorisation of global economies.
2 Worldwide GDP fell by more than 15% during the Great Depression and more than 10% in 1946, the year following World War II (Dominguez, 2017; Yeyati & Filippini, 2021).

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Part I

Appeal

2 Attractiveness

How to Make a Smart City Revitalise Its Charm during and after a Pandemic

1 Introduction

In order to thrive, a city needs to be an attractive place in which one wants to live and conduct business. Equally important is that the city is a place to which denizens and businesses want to commit themselves and where they will want to stay for the long haul. Because the greater a city's attractiveness, the greater the incentive to keep it strong and resilient. However, in order to be attractive, a city needs to be more than just innovative. There are a number of factors that affect the attractiveness of a city (Capponi et al., 2019; Caragliu & Del Bo, 2012; Lombardi, Giordano, Farouh, & Yousef, 2012; Matos, Vairinhos, Dameri, & Durst, 2017; Snieska, Zykiene, & Burksaitiene, 2019). Essentially, there are two kinds of attractiveness that must be accounted for. The first is the attractiveness to individuals, (so that they will want to move to the city) and the second is the attractiveness a city has towards businesses and investors (so that the city may thrive economically).

Some may think of this as "competitiveness", but this term can be somewhat misleading. As Michael Porter (1980, 1990) noted, competitiveness can be represented at several layers. Especially so when engaging economic angles, whereas attractiveness, in this context, has a more directed and specific focus about gaining traction to a specific city.

The obvious question that follows is "what then is 'attractiveness'"? Admittedly, "attractiveness" per se is an exceptionally difficult term to define since it carries so many different connotations in so many different contexts (Sinkienė & Kromalcas, 2010). In a city context, some prior studies have defined it as the appeal for firms of carrying out activities in a particular urban area (Van den Berg & Braun, 1999). However, this is a somewhat problematic definition since it would make the size of the production that firms achieve in one location contingent on the comparison to what they produce in a different city. Instead, OECD (2011, p. 132) offers a more refined definition, in which attractiveness is based on four factors: (1) expectations over the production volume; (2) capital returns; (3) market size; and (4) local environment conditions. A more encompassing definition that this chapter seeks to adhere

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to, is offered by the European Urban Charter (Council of Europe, 2009, p. 49), which describes an attractive, ideal, city as:

> [O]ne which succeeds in reconciling the various sectors and activities that take place (traffic, living working and leisure requirements); which safeguards civic rights; which ensures the best possible living conditions; which reflects and is responsive to the lifestyles and attitudes of its inhabitants; where full account is taken of all those who use it, who work or trade there, who visit it, who seek entertainment, culture, information, knowledge, who study there.

Hence, increasing the attractiveness of a city is by and large a matter of effective governance. Expressed more directly, establishing a vision for a smart city requires a well-conceived governance framework. This framework needs to be able to integrate all of the aforementioned political, social and economic aspects, while also managing the investments in infrastructure and services needed to produce optimal returns in terms of public value and benefits (Dameri & Benevolo, 2015).

Hence, it is imperative that the governance of the smart city is effective in ensuring the implementation of a digital transformation, while securing that it is constantly ongoing and able to keep up with technological advancements in different areas of society. Likewise, the governance must also ensure that any and all political and administrative activities are grounded in tested and well-established practices in order to ensure legitimacy as well as credibility. However, the present dearth of smart city governance instruments is a well-known problem, and one that could pose a formidable barrier to successful policy implementation (European Parliament, 2014). This has many consequences for the attractiveness of the city, since increasing a city's attractiveness is contingent on an effective means of governance.

The aim of this chapter is to explore how decision makers in a smart city (e.g. local governments, nongovernmental agencies and administrative officials) can enhance and/or sustain the city's attractiveness to existing and potential future denizens and enterprises through governance even following a pandemic such as COVID-19. By mapping the involvement of various political elements (such as city council, city government, and city mayor) in governing smart cities, this chapter seeks to understand if empirical implementations of smart cities accurately reflect pre-existing theoretical frameworks, which stipulate that there must be strong institutional and political bodies in order for a smart city to be successful (Chourabi et al., 2012; Nam & Pardo, 2011).

2 City Branding/Attraction-Oriented Strategy

2.1 Cities as Brands

City branding is a tactic used to increase a city's attractiveness (Anttiroiko, 2014, 2015). To this end, city branding may oftentimes benefit from adopting an attraction-oriented strategy. Such a strategy "aims at effective absorption of external resources from the global space of flows" (Anttiroiko, 2014, p. 1). Essentially, this means creating a systematic approach towards securing attractiveness. On the operational side of attractiveness, there are promotional activities and incentives intended to tempt the recipient (Anttiroiko, 2014). Those city officials yielding power, be they mayors, councillors or any other type of politicians, are in constant "competition" with other cities in terms of attractiveness. In a way, cities are much like brands. That is to say that cities will need to grow and attract new resources, whether it be in the form of human capital, labour force, organisations, businesses, investors etc. and that cities, much likes brands, will need to be able to "define where their unique attractiveness lies, or what is known as positioning" (Kapferer, 2008, p. 126).

City branding and/or marketing is often associated with tourism, but in some cases (chiefly for business purposes) it occurs in the form of lobbying. Halachmi and Meng (2013, p. 91) recount an example of city branding from the music industry in Nashville, Tennessee.

> In Nashville, lobbying of city officials and accentuating the potential side benefits of expanding music related businesses and services were the main ways of mobilizing support from city officials.

Notwithstanding, employing an attraction-oriented strategy goes well beyond the scope of mere branding/marketing as it seeks to increase the attractiveness in so many other areas as well.

2.2 Agglomeration – The Process of Sharing, Matching and Learning

While it may be tempting to think of globalisation as the big "enabler" that creates international awareness of other cities, some of the drivers of creating attractiveness are much older than that, and these drivers are much still valid. As noted already in the late-1800s by economist Alfred Marshall (1890), workers in skilled occupations more often than not cluster in areas where their peers live and work. This was compounded in the case of couples, meaning that women entering the labour force also served to speed up the trend (Costa & Kahn, 2000). To that end, employees are more willing to relocate to an area that promises a future beyond one's place of work, i.e. one that holds features attracting an influx of high-skilled denizens, is in many ways a signifying feature of a cosmopolitan city. A couple of concrete examples can be seen in the Los Angeles film industry which has spawned a wide-ranging cluster of supporting industries, such as sound recording, animation, visual effects, photographic equipment and talent agencies. The proximity to one another serves to reduce each studios' costs for accessing the inputs needed from one another (Berube & Parilla, 2012). Another example where clustering of competency has been instrumental, is the Chinese town of Hangji, located in the Jiangsu Province. Consisting of a mere 120 km^2 and a population of 35,000, it produces 30% of the world's toothbrushes and 80% of all the toothbrushes in China (Wang, 2009).

While Marshall's theories chiefly pertained to firms receiving increasing returns, his theory posited that the economy of agglomeration is founded on the existence of a trinity: (1) a local pool of skilled labour, (2) local supplier linkages and (3) local knowledge spill-overs (Potter & Watts, 2014). Or expressed more succinctly; *sharing*, *matching* and *learning* (Duranton & Puga, 2004). However, this trinity is also extant in modern, smart cities because this environment fosters a sense of ease of settling in while adapting to a new home. By extension, this ultimately impacts work productivity (Romão, Kourtit, Neuts, & Nijkamp, 2018; The Place Brand Observer, 2016).

2.3 Knowledge Development as an Attractor

Urban studies theorist Richard Florida (2014, para. 4) describes cities' attractiveness in terms of talent in the following way:

> The communities that attract and retain talent are open to all, regardless of gender, age, sexual orientation, race and ethnicity. But they must be more than open; they must be proactively inclusive. And that means providing not just tolerance but opportunity and engagement, making it easy for people to plug in and follow their dreams.

What Florida is describing is a city that has the necessary prerequisites to coordinate the work of all place-stakeholders within the cohesive place-context, whether it is a question of policymakers, business enterprise, academics or any other member of the civil society (Stubbs & Warnaby, 2015). Attracting talent requires a cohesive form of stakeholder collaboration. Beyond that, there are a number of central features that increases the attractiveness for talent, such as the presence of a university. Granted, the overall quality of education and career opportunities are essential factors for people choosing the institution per se. Nevertheless, cities can increase the appeal of universities by highlighting various integration programmes and reaching out to different walks of life as to why an education at that university would better people's lives and future opportunities. Somewhat adding to this point, while challenging Florida's overarching approach towards urban renewal, is Harvard economist Edward Glaeser's (2005) contention that it is rather the educational levels that correlate with metropolitan economic development. The notion here is that universities serve a "push-pull" function in making cities attractive. On the one hand, they need to appear desirable enough for prospective students who want to choose it, on the other hand the success rate of the people who have studied there will help foster a favourable narrative for the city while also generating a pool of competence the city can tap into (barring possible "brain-drain", of course).

Apart from tax incentives, the availability of skilled labour is the main determinant for a city to succeed in terms of attractiveness for enterprise and for investors (Baldwin & Bax, 2019; Parilla & Liu, 2019; Tuccio, 2019). That is to say, businesses are looking to capitalise on the high density of talent clusters. This means that they often seek out universities and try to establish themselves in places where future workforce pools can be found. This helps foster long-term talent retention. Put simple, cities that work closely with academic institutions and cities in which businesses are working together, have the best preconditions for creating shared value. This, in turn, develops a strong sense of talent attractiveness. Successful cooperation between cities and universities means that the latter effectively works as a talent incubator for the former. Collaboration also enables the city to develop and adopt strategic programmes and policies aimed at retaining talent. In that way, cities are able to meet the needs of the newcomers and potential future denizens. As explicated by Anttila and Jussila (2018), universities need to serve as role models, and contribute both scientifically and educationally to the development and dissemination of knowledge in society. The authors also assert that many times, various types of city development projects occur in smart cities in which various public and/or private actors collaborate, and that universities should take a greater part in these projects and make their presence more visible.

Moreover, universities are able to contribute by raising the quality of education for students. Cooperation between the triple helix of city-business-academia can help talents to reduce the risk of skills mismatch. Alternatively, in some dense cities, this can be done with little inference (if any at all) from the triple helix, since a greater number of potential employers and employees assembled in the same place will raise the average likelihood of securing a good match (Chung, Lee, & Cho, 2021; Helsley & Strange, 1990). Nevertheless, mismatched skills are a salient problem that may lead to unfilled jobs and missed opportunities for talent retention. This was clearly seen in the case of the Irish property bubble in 2007, in which speculative excess element of a long-term price increase of real estate ultimately served as a major contributing factor to the post-2008 Irish banking crisis (O'Sullivan, 2020). During this time, many Irish workers found themselves with skills unrelated to the growing high-tech sector (Britannica Educational Publishing, 2014; O'Callaghan, Kelly, Boyle, & Kitchin, 2015; Ó'Riain, 2012). A city's ability to foster, attract and retain skilled workers is, beyond offering the best life conditions, contingent on the ability to sustain businesses and job opportunities in different ways, while providing for alternate routes and reskilling in the event that it should become necessary. In that way, the ability for the city to collaborate with the educational institutions to nurture the extant and potential labour capacity is a determining factor in the city's ability to position itself as an attractive location for work and, by extension, future investments.

Still, it is important to remember that money is not the sole driver. This is a contention that is particularly expressive for the next generation of workers. Several studies have indicated that although the level of remuneration is indeed a top consideration when accepting new job opportunities, it is not necessarily the only, or even most important, one (Kelly, 2022; Tirta & Enrika, 2020; Troger, 2021). A part of the aforementioned ability to offer favourable "life conditions", is also the ability to offer work–life balance, professional development and advancement opportunities (Yap & Zainal Badri, 2020).

2.4 New Generations Making Their Imprint on Cities

Since 2016, so-called Generation Y, or more popularly, "Millennials" (i.e. people born between 1982 and 2000) represent the largest component (50%) of the available workforce, at least in the developed countries (Fry, 2018; PwC, 2011; United States Census Bureau, 2015). As of July 1, 2019, Millennials numbered approximately 72.1 million in the US alone (Fry, 2020). By 2030, this group is expected to account for 75% of the US workforce (Bingham & Conner, 2015; Breckenridge, 2021). Many Millennials prefer living in eco-friendly, walkable neighbourhoods with mixed amenities, while opting to use bicycles or public transport as their main mode of transportation (Haber, 2016; K. White, Hardisty, & Habib, 2019). Earlier research, and more particularly that which draws upon spatial equilibrium theory, has held that higher wages may outweigh the lack of amenities (Roback, 1982). Assuming that indeed holds stronger, or at least equal, preference to other factors beyond wage as the aforementioned results would suggest, Millennials would favour cities that offer them a good mix of different activities. This, in turn, means that cities that wish to attract Millennials would need to cater to their needs and desires. This also includes providing jobs that lie closer to the residential areas, because according to a study by Nielsen (2014), 62% of Millennials prefer living in a home that is close to shops, recreational activities and work. This is a task that smart cities are equipped to handle because digital technology makes it easier for companies to move jobs to where the talent is, rather than the traditional practice of people moving to where the jobs are.

As Millennials are moving up in their career taking on an increasing number of managerial roles, Generation Z, or iGen (born between 1995 and 2012)[1] with their 74 million people strong cohort in the US alone, have begun to make their entry into the labour market (Gabrielova & Buchko, 2021). By 2030, almost every entry-level role in the US is expected to be filled by a member of Generation Z (Al-Asfour & Lettau, 2014). Generation Z is unique inasmuch that they are the first generation to be "smart city natives". "Smart technology" has always been part of their lives and their mobile phones have always been "smart". While Generation Z shares many traits with Millennials, Generation Z brings in new patterns of behaviour given their "smart nativeness" (Gabrielova & Buchko, 2021; Iorgulescu, 2016). Extant studies have suggested that, by and large, Generation Z value flexibility in the workplace (Gabrielova & Buchko, 2021; Ozkan & Solmaz, 2015). Much like Millennials, they are interested in seeing quick value for their efforts, however, unlike the Millennials, Generation Z has been less about face-to-face communications and is not as comfortable writing letters and handling calls since much of the communication occurs in the form of short text messages (SMS), emojis and videos (Breckenridge, 2021; Gabrielova & Buchko, 2021). While they are more prone to being socially connected with most people in their surroundings, including their managers, Generation Z is also likely to require feedback on a regular basis (Turner, 2015).

Thus, smart cities will need to be diverse in their design (Harrison, 2017). While quality work–life balance a proximity to a varied assortment of amenities will play a huge role in where Millennials (and possibly also Generation Z) relocate, a number of these factors are also contingent on age. For instance, students and childless young professionals would tend to look for more "hip" environments, such as nightlife options and travel capabilities to a greater extent than other categories of people. As these people start families, their priorities tend to shift towards ensuring housing affordability, where they would tend to favour living in "calmer" and more eco-friendly neighbourhoods, while also emphasising the need for public services centring on childcare, education, healthcare etc. (Auslander, 1997; Karamujic, 2015). For instance in 2022, the urban area of Öjersjö, located northeast of Gothenburg, Sweden, built 8 four-storey houses with 81 residential units in a complex called *Ramselyckan*. The complex featured wooden siding, large windows and large grounds surroundings, while also being supported by geothermal and solar heating in order to make the project more energy-efficient (Oslo Børs, 2021).

Image 2.1 Residential complex of *Ramselyckan*, located in Öjersjö, outside Gothenburg, Sweden. The complex features wooden features, large windows and large ground surroundings.

Source: HSB Göteborg.

2.5 Good Governance Can Enhance Attractiveness

Another governance aspect that affects attractiveness is the political stability and the perception of a free and transparent political system. Much like any other city, even smart cities are vulnerable to the perils of corruption. Corrupt governance has undermined credibility in several cities (whether they are smart cities or not), and regrettably the list of corrupt city officials around the world is long indeed (Barber, 2013; Easterly, 2001). Citizen participation is an integral part of any truly democratic system, but in order to participate in a sensible way, people must also keep themselves informed (Yang & Pandey, 2011). A key component in this is transparency, which, in and of itself concerns access. While access to information is quintessential, transparency is also about access to the decision-making process itself, and the possibility of holding those in charge accountable for their actions (Bertot, Jaeger, & Grimes, 2010). In this way, the more transparent a society is, the more difficult it is for corruption to thrive (Kolstad & Wiig, 2009). On this account, smart cities have the ability to foster citizen participation and the democratic process due to their ability to help strengthen transparency (Berntzen & Johannessen, 2016).

By offering self-service access to information, denizens are able to acquire information irrespective of time and geographic constraints. Self-service through digital devices is economical, as the costs for keeping information online are negligible as opposed to providing personal, human-assisted services around the clock. Public entities produce much data, and there have been increasing demands since the 1980s for as much data as possible to become "open" (K. Janssen, 2011; M. Janssen, Charalabidis, & Zuiderwijk, 2012). By making data sets freely accessible, it is possible to perform various forms of cross tabulation, visualisation, mapping etc. of said data, to make it more comprehensible to the public (Gurstein, 2011). In many cases, governments and city officials have launched various data portals where government entities can publish available data sets in open and machine-readable formats. A few examples of these include "Data.gov" in the US, "data.gov.uk" in the UK, and "data.norge.no" in Norway (Johannessen & Berntzen, 2017). In Estonia, it is even possible to become an "e-Citizen" (or "e-Resident"), which also provides foreign nationals with the ability to apply for a secure digital residency in Estonia and the ability to access a variety of digital services, even if they do not physically reside in Estonia (Tammpuu & Masso, 2018).

2.6 Data Accessibility

On July 16, 2019, the European Union (EU) introduced *Directive 2019/1024*, more popularly known as the "Open Data Directive". This directive sought to make public sector and publicly funded data re-usable. It replaced the prior *Directive 2003/98/EC*, known as the "PSI Directive", which focussed more on the economic aspects of the reuse of information rather than on access to information by citizens (European Parliament and the Council of the European

Union, 2019). Notwithstanding, many governments around the world restrict the accessibility to data that would otherwise be deemed as safe for public consumption (M. Janssen et al., 2012). Another problematic issue is that while some cities claim to have "open" accessibility to data sets, the selection is random and rarely allows for comparison between different municipalities (M. Janssen et al., 2012; Taubenböck et al., 2012). Transparency, accountability, maximised citizen participation and increased trust are some of the most prominent benefits of open data (M. Janssen et al., 2012). In this way, data journalism may become essential to cities seeking to maximise their transparency.

What then is "data journalism"? Essentially, it is a form of investigative journalism that relies on sources such as statistical data, open data repositories and other digital sources (Appelgren & Nygren, 2014). In one way, data journalism is an amalgamation of different scientific fields, such as statistics, computer science and data visualisation (Coddington, 2015). There are a number of prominent examples of actors who engage in data journalism. For instance, during 2009–2010, the British newspaper *The Guardian* published 460,000 pages of government expense reports online, asking its readers to examine the documents for questionable items (Johannessen & Berntzen, 2017). This led to multiple critical news articles, and some members of parliament were ultimately compelled to pay back parts of the purported reimbursement money they had claimed in travel expenses (Coddington, 2015). The Knight Foundation (2019) is another proponent of data journalism, data-driven journalism and invested US$50 million in 2019 towards development around the field of research on how technology impacts democracy. Another example is the American think-tank the Pew Research Center, which will oftentimes make use of data in their journalistic practices (Ritterbush, 2009).

Smart cities can help improve the transparency in many different fields, thereby increasing the city's attractiveness. For instance, policy development documents can be made readily available on the website or digital portal of the city's governing body. Ensuring transparency of the city's decision makers is essential in order for the denizens to garner an accurate understanding of who they are and whose interest they are likely to serve, should there be any potential conflicts of interest, etc. in their professional role. This involves full disclosure of all matters relating to owner interests, board memberships etc. Also, voting records and their spending of public funds (e.g. travel expenses) will also be of interest to the people electing them. Information should also be made available regarding personal connections/affiliations that may influence the jobs of the decision makers/politicians, since this may affect their political agenda. While it would most likely require new laws on a national level in order to mandate all city politicians to participate in such a registry, decision makers could be advised/encouraged to participate in a voluntary register, while data journalists could be free to disclose for the public those decision makers who have chosen not to participate.

To this end, the cities should allow for a process of "benchmarking" in which it would be possible to compare the governance and the performance of various public sectors with that found in other cities around the country in order to determine which entities perform better while identifying best practices (Keehley, Medlin, MacBride, & Longmire, 1997). These results could then be used to improve the city's functions further, thereby increasing its attractiveness. Benchmarking relies on quantifiable data, and in the event that such data is publicly available, it would be possible for denizens and/or interest groups to conduct their own benchmarking of results. Multiple data sources are relevant for benchmarking. This includes annual reports, user survey results, demographic data etc.

The ability for denizens to follow the political process also benefits transparency, and digital technology makes those processes simple. In concrete terms, transparency can be increased through the online publication of the location and time of political meetings so that the public can stay informed as to when these political debates are taking place. The agenda/proceedings and the subsequent minutes, along with transcripts from the meetings/debates should be made readily available, ideally on the local government's website. The actual meetings could be made available via webcast, with the videos both streamed "live" and subsequently uploaded on the website so that they can be viewed at a later date. A wider use of webcasting also has the potential of increasing the denizen's influence over local politics, since interest groups would have an added means of identifying politicians supporting their cause, and could reach out to them and feed them with constructive arguments to use in the debates.

3 Improving a City's Attractiveness Following a Pandemic

A pandemic such as COVID-19 brings on many changes for a city, given the fact that most cities are highly susceptible given their high density of population. Many cities have suffered under the COVID-19 virus. For instance, New York City had accounted for 15% to 19% of all COVID-19 deaths in the US in late 2020 (Tucker, 2020). This is despite the fact that New York City merely represents 2.5% (or 1/38) of the national population (NYC Planning, 2022). London, on the other hand, accounted for more than 1/5 (21%) of all COVID-19 deaths reported in England and Wales during the same time period, while representing roughly 13.4% of the national population (European Commission, 2021; Morris & Barnes, 2020). Madrid was grossly overrepresented, as it accounted for roughly 35.55% of all COVID-19 deaths in Spain during the period March 3, 2020 (when the first death was recorded) to June 8, 2021 (Zoran et al., 2021).

Modern era cities have not been designed to account for highly transmissible pandemics, such as COVID-19. Cities are inherently crowded by design and vast open, green spaces are a commodity in many big cities. The compactness of everything from public transport to entertainment and culture stipulates that there will virtually always be some form of proximity to other human beings. Still, the spread of COVID-19 has entailed the implementation of some fundamental changes to the society at large. COVID-19 has already produced some tangible changes. For instance, in Athens, Greece; Bogotá, Colombia; and Milan, Italy, streets were retrofitted into bicycle lanes, while pavements were widened in order to allow people additional means to travel while also encouraging social distancing (Smith et al., 2020). Another example is Paris, France, which in April 2020, proposed to create some 650 km of cycleway following the COVID-19 pandemic (Turoń & Kubik, 2021).

In Rotterdam, the Netherlands, and San Francisco, USA, public spaces, e.g. parking spaces, walkways and plazas, were converted into commercial retail spaces so that businesses that were severely affected by the pandemic would be able to serve their customers in a safer manner (Fracassa, 2020; Serhan, 2020). Toronto, Canada and New York City, USA installed "social-distancing circles" in their parks in order to prevent overcrowding (Feinstein, 2020; Harrouk, 2020; Serhan, 2020). Dining habits across many cities also changed during the pandemic, with many cities imposing restrictions on the number of people allowed per table, how to serve food, etc. Outdoor dining, or "alfresco dining" became more popular (Clark & Brown, 2021). Also, there was a surge of so-called streateries in many cities (Combs & Pardo, 2021). These are essentially spaces set up by restaurants looking to serve customers while following social distancing regulations, and may, in some cases, even expand their outdoor seating by using spaces previously dedicated to other purposes, such as pavements, parking spots or even the street itself.

Image 2.2 Pearl Street, Brooklyn, New York City, before and after retrofit.
Source: ©2007–2008. New York City Department of Transportation. All rights reserved.

Urban green spaces (UGS) are also important factors in keeping a city attractive and helping the denizens find a sense of bliss in an otherwise bustling urban environment (Larsson & Hatzigeorgiou, 2022). Studies have shown that nature within urban settings will have a central role in helping address key global public health challenges associated with urbanisation such as depression and high blood pressure (Shanahan et al., 2016; Zhang, Yu, Zhao, Sun, & Vejre, 2020). Other studies have shown that trees can improve urban air quality as leaves and pine needles capture air pollutants from the air (Klingberg et al., 2022). Moreover, in locations with warmer climate or already lower green/UGS coverage, UGS is known to be one of the most effective strategies for alleviating the impact of urban heat island, i.e. a metropolitan area that is significantly warmer than its surrounding rural areas due to human activities (Solecki et al., 2005; Yao, Li, Xu, & Xu, 2020). Then, how much green space should a city have? Studies have recommended that at least 9 m^2 of green space per individual with an ideal UGS value of 50 m^2 per capita is appropriate level of greenness in a city (Russo & Cirella, 2018). This is roughly equivalent to a little over four parking spaces (the average UK car parking space is 12 m^2) (Ison & Budd, 2016).

Of course, one may debate what kind of UGS would be more desirable, a well-kept, but man-made, park? Or something more natural and unkempt, such as fields, meadows and/or groves, etc.? This question is rather a matter of the geographic preconditions in the cities. While some cities/locations may be blessed with lush vegetation, it may be bereft in others. According to the World Health Organization (WHO) (2017), a diversity of different kinds of green areas is advisable (if achievable). However, as mentioned, there is a dearth of green areas in some cities. In these cases "green landscaping" may present itself as an even more so viable option. One example in which a form of "green landscaping" has been done in an exceedingly urban environment without much access to "naturally" occurring greenery is the High Line, a 2.33 km (1.45 mile) long elevated linear park, greenway located in Manhattan, New York City (King, Bourdeau, Zheng, & Pilla, 2016). It was built on the abandoned/disused, southern viaduct section of the New York Central Railroad's West Side Line (Zuccaro, 2020). Completed in three phases during 2009–2014, it has since become a popular symbol of green landscape redesign of obsolete infrastructure into green, vibrant public spaces (Ghosh, Byahut, & Masilela, 2022).

While the positive effects of green areas are known, it has proven to be more difficult to prove a causal relationship as to exactly how green areas impact positively on one's health (Lee & Maheswaran, 2011). In this sense, future digital technology might proffer an essential tool, which can help urban planners determine where the best effects would be in the event of green landscape redesign.

The concept "smart urban forests" refers to applications of digital technologies for managing different facets of urban forests, e.g. tree monitors and 3D-imagery (Prebble, McLean, & Houston, 2021). In this way, "smart urban forest" projects could utilise various monitoring techniques using sensors and

Image 2.3 High Line, Manhattan, New York City. An example of green landscape redesign of obsolete infrastructure into green, vibrant public spaces.
Source: iStockphoto.

Internet of Things (IoT) technologies, e.g. monitoring soil health, measuring air pollution, and ensuring adequate hydration of urban forests (Gabrys, 2022). Other advantages are the addition of open data and citizen engagement (chiefly by means of mobile device applications (i.e. "apps"), and other open-source mapping platforms (Nitoslawski, Galle, Van Den Bosch, & Steenberg, 2019). One example of this is the "Treepedia" research initiative. Launched in 2016 by MIT Senseable City Lab in Massachusetts, Treepedia aspires to raise awareness of urban forests by using digital vision techniques based on Google Street View images (Walker, 2018). Outlining multiple cities around the world, Treepedia focusses on pedestrian street trees rather than trees and greeneries in parks etc. since pedestrians are more inclined to serendipitously come across the former rather than the latter, as it generally entails an active choice to seek out those green areas (Duarte & Ratti, 2018). Using an open-source library, the project includes the complete set of programming code in order for the public to use it to calculate the quantities of tree coverage for their own city or region (Duarte & Ratti, 2021).

City aesthetics are also known to factor into the city's attractiveness (Green, 1999; M. J. White, 1985; Widgery, 1982). Cities which are able to integrate urbanisation with the natural environment, such as rivers etc. often succeed in becoming more visually attractive (Batista e Silva, da Graça Saraiva, Loupa Ramos, & Bernardo, 2013; Nasar & Li, 2004). In this, Lisbon, Portugal; London, UK and Stockholm, Sweden, being notable European examples of smart cities with a high degree of urban/water area integration (Batista e Silva et al., 2013; Bibri, 2020; Pinch & Munt, 2002). Buildings/infrastructures are also essential components to adding aesthetic value.

What then constitutes "aesthetic value"? The question is not an altogether easy one to answer. As per the expression once coined by Margaret Wolfe Hungerford (1878, p. 206): "beauty is in the eye of the beholder". This also applies to perceptions of what makes building look attractive, as stylistic preferences vary immensely. In fact, there is even research supporting that one's aesthetic preference for particular architectural styles may be a function of one's personality (Cook & Furnham, 2012). Notwithstanding, attempts have been made to delve deeper into what increases the likelihood of buildings of being perceived as more attractive. For example, the impact of tall buildings (admittedly an ambiguous term that varies from place to place) is known to vary from building to building and across different cities (Karimimoshaver & Winkemann, 2018). However, a study by Heath et al. (2000) indicated that higher levels of perceived silhouette complexity were more favourably received. Other studies have suggested that it is more a matter of to what degree a tall building is visible that matters (Czyńska & Rubinowicz, 2016; Rød & van der Meer, 2009). Conversely, a study by Van der Hoeven and Nijhuis (2012) contended that individual buildings are of a lesser concern, that it is more a matter of how the buildings are perceived as a cluster.

Regardless of one's perception, city architecture is a concept that divides many people. During the 1964 *Jacobellis v. Ohio* ruling, the United States Supreme Court Justice Potter Stewart (1915–1985) famously quipped, "I know it when I see it" as a candid shorthand description of a practice in which one attempts to categorise an obvious and observable fact to which there is no defined parameters and thus remains a topic for subjective assessment (Gewirtz, 1996). This contention is in no doubt shared by many laymen in regard to what makes a city visually attractive, albeit with an added layer of complexity regarding the highly subjective nature of "beauty". Between the 1890s and the early 1900s, there was, across the US, an interest group, or a movement, called the "City Beautiful movement" that sought to promote a landscape that premiered beauty and civic grandeur, but also raised aspirations for a more humane and functional city (Mohanty, 2022). The City Beautiful movement gathered architects and planners, businessmen and professionals, and social reformers and journalists, which would initiate dialogue with the legal authorities and city planners, and became prominently reflected in the plans of Chicago, Cleveland and Washington, DC (Mohanty, 2022; Revell, 2005). There are, in no doubt, many polarising views regarding the aesthetics promulgated by the City Beautiful movement, and it is true that the initiative eventually ended due to its dwindling capacity to engage the business enterprise (Mohanty, 2022). However, the movement did manifest the initial tour de force of bringing together various concerned parties and organising, and engaging, in dialogue with various lawmakers and city authorities. This is a concept that could be developed further and revamped in regard to holding a more open dialogue in regard to the visual aesthetics of the future smart cities.

As stipulated in the preceding sections, the cornerstone of increasing a city's level of attractiveness is making opportunities more accessible and making the society more transparent and credible. The effects brought on by a pandemic will often have devastating effects on the physical accessibility to different parts of the city, while also carrying detrimental effects on the opportunities the city is capable of providing. Pandemics tend to bring many negative attributes to society, including large-scale public despair, market uncertainty, skyrocketing unemployment rates, and massive supply side disruption. For that reason, strong, collective efforts are needed to protect the society at large, lest there would be a long-lasting depression that could jeopardise not only the economy of the city, but also the political system (Ahmad, Stern, & Xie, 2020; OECD, 2020; Söderström, 2021). Therefore, safeguarding the core tenets of what it is that makes a city attractive must continue to be paramount, even after the pandemic has tapered off.

Addressing the House of Lords in 1943, Winston Churchill famously said: "We shape our buildings and afterwards our buildings shape us" (Keyes, 2006, p. 19). While the long-term effects of COVID-19 are still unknown, there has been an ongoing academic debate regarding to what extent the pandemic will change the actual physical makeup of cities (Afrin, Chowdhury, & Rahman, 2021; Bereitschaft & Scheller, 2020; Sharifi & Khavarian-Garmsir, 2020). However, some of the most profound changes will be in the behaviour and attitudes among the denizens. The pandemic has prompted many companies to enable the possibility to work from home, in many cases there were companies that previously lacked either the tradition or the technical capabilities for enabling this possibility. Given the fact that this possibility now exists for many people, it is likely that many people, particularly those belonging to the younger Generation Y/Millennials (and Generation Z), will want to continue having this possibility, with the added option of having a physical job location to go to for whenever needed or for meeting work colleagues and managers. However, this is a matter that will ultimately be decided by the market rather than by the employees themselves. Admittedly, there will always be jobs that cannot be done remotely, such as the majority of jobs in the hospitality and some retail sectors, as well as in healthcare among many others.

Notwithstanding, the pandemic undoubtedly served as a catalyst to push the digitalisation of society and the economy even further. The transition to working from home carries other ramifications as well. The more people staying at home to do their jobs, the less people to use public transport during rush hours, meaning reduced risk of spreading and contracting the COVID-19 virus. There is some suggestion that the spread of COVID-19 will lead to an increase in demand for housing outside the cities, even if many younger denizens will continue to prefer to live centrally in the cities (Newman, 2020; Rightmove, 2020; Serhan, 2020).

As countries and cities around the world gradually moved from a rescue phase to a recovery phase, top priorities were given to handle the public health emergency and preventing further spread of the disease, while at the same time trying to salvage the economy as best as possible. This includes the need to stimulate the level of employment as well as providing help and support to the banking system ensuring the supply of finance and liquidity to support viable corporations and instil confidence in the economy overall (De Henau & Himmelweit, 2021; Elnahass, Trinh, & Li, 2021). This includes defining clear strategies for growth while linking short-term actions (one year or less) to medium-term expectations (approx. 1–2 years), while also ensuring that potent stimulatory fiscal and monetary policies (that acknowledge the need for substantial deficit financing) are set in place (Dubovik, Gubarev, Sizova, & Sizova, 2020; Rasul, 2020). These policies would likely entail the need to both borrow and create money. At the same time, it is important to keep a cool head and not get carried away by responding to the accumulating public debts with implementations of overly tight fiscal policies during the rescue period as a means of responding to the escalating costs brought on by the pandemic. The reason is that, doing so, would have a boomerang effect by severely risking stymieing the recovery while plunging the economy into an even worse subsequent recession. Ideally, a recovery period should carry the characteristics of a global transformation of the city to a sustainable, strong and resilient place of economic development and growth. The main edge smart cities hold over other cities in this regard, is their ability to produce, process, utilise and make accessible large sets of data. Beyond the recovery phase, one may also consider a "reinvention phase", where a form of "double-loop" learning is applied, where those in power are able to learn and improve from pandemics/disruptions and are able to make necessary adjustments in order to enhance the resilience for future occurrences.

Historically, the national government was always "the primary site and scene of population data collection […] for nearly four centuries" (Ruppert, Isin, & Bigo, 2017, p. 4). However, in later years, along with the advancement of digital technology, the states have essentially lost their monopoly over data and data management. In later years, this monopoly has become increasingly questioned by both private corporations as well as by citizens. For this reason, different types of data have come to serve different purposes in the smart city design. An important concept in this is "platform capitalism".

Here, "platforms" entail large-scale multi-national organisations (such as Google, Microsoft, Facebook etc.) whose business model concerns in one way or another, the sourcing, processing and monetisation of data (Srnicek, 2017). "Platform urbanism" is a derivate in which digital platforms (such as Airbnb, Uber, Deliveroo etc.) produce vast quantities of urban data to manage their services (Barns, 2018; Leszczynski, 2020; Söderström & Mermet, 2020). Their control over data and code makes them difficult to regulate. It is also this control that assists them in increasing their (and ultimately the city's) attractiveness while also staying in control of the market so that customers use their services in their everyday lives. Intrinsic to these platforms is that they possess an "urban" character and they more often than not depend on city geography for their data, service offerings and uptake (Barns, 2020). While the services currently provided under platform urbanism are in essence still facile, there are deeper and more advanced developments in the pipeline. This includes platform-based urban governance systems, such as city operating systems and even the type of "social credit systems" that exist in Chinese cities. This development would herald the dawn of new data-driven experience that is expressed, monetised and controlled by means of the urban platform.

In essence, one may consider platform urbanism to be a second mode of existence of the smart city (Söderström, 2021). The practical management of pandemics will be very reliant on the cooperation of tech corporations in e.g. contact tracing. For instance, survey data from Facebook and Google has the potential to map the spread of COVID-19 (Goode, 2020). Some tech companies, such as Apple and Google, purport to be developing a tracing software system which is supposedly more protective of privacy and civil rights, while at the same time also more compatible with political leadership, that is, if not democratic, at least less authoritarian (Söderström, 2021). Moreover, governments in various countries/cities are taking on own initiatives towards developing technology focussing on public health interventions. One example of this is Singapore, with their software programmes "TraceTogether" and "SafeEntry" (Kuguyo, Kengne, & Dandara, 2020).

4 Conclusion

The aim of this chapter was to explore how decision makers in a smart city (e.g. local governments, nongovernmental agencies and administrative officials) could enhance and/or sustain the city's attractiveness to existing and potential future denizens and enterprises through governance even following a pandemic such as COVID-19.

Action 1: Adopt an Attraction-oriented Strategy

Smart cities will need to adopt an attraction-oriented strategy in order to brand/position their city to attract new residents and businesses. A part of such a strategy should be to coordinate the work of all members of the civil society and a part of doing so is to secure a successful digital transformation of as many public services as possible. This also ensures that there is accessibility to information, which demystifies and helps enhance the transparency of the decision-making process, while also encouraging the city residents to stay more informed and take on a more active part in influencing the future of the city's development. The openness, transparency and active democratisation of the cities will lead to a greater sense of credibility and political stability for both residents and businesses.

The action-strategy should also look to attract skilled labour and ensure a high density of talent clusters, as well as attracting back those denizens who may have moved out due to the pandemic. This involves ensuring that the city has capacity to provide means of higher learning to its denizens, so that skills can be cultivated and aggregated within the city. This will also attract companies seeking to recruit talent and thereby also fostering long-term talent retention. It also provides means to reskill talent who has found their current businesses made either obsolete or unprofitable by the advancement of technology or changed habits in society. While the pandemic might prompt some residents leave the city centres and move to more isolated areas in the outskirts, the drivers of Generation Y/Millennials will still largely concern the desire to achieve a work–life balance, while at the same time live in close proximity to work, home and entertainment. For this reason, the technological preconditions should be made available so that people may have the possibility to work remotely if necessary and feasible. In many cases, this would also be a precondition to keep the economy running during potential lockdowns.

Action 2: Cooperate with Big Data Companies to Bring Open Data

Cooperating with Big Data companies will be essential to combat the spread of the diseases further. Making the data "open" (i.e. publicly available for anyone to use, and licensed in a manner that allows for its reuse) can help facilitate the perception that Big Data is useful, more democratic and non-threatening (Ferraris, Leucci, Bresciani, & Giunchiglia, 2016). At the same time, the powers that be must also ensure that the denizen's integrity and privacy is upheld and protected throughout, and even after the end of, the pandemic (Kitchin, 2020). Moreover, platform urbanism will likely become an integral component of the post-pandemic smart city.

Action 3: Focus on Public Health Emergencies during the Rescue Period and on City Transformation during the Recovery and Reinvention Period

During the rescue period, the cities need to focus on handling the public health emergency and preventing further spread of the virus, and doing as much damage-control as possible on the economy. However, during the recovery period, the city needs to focus on transforming itself to an even stronger, more sustainable and resilient place of economic development and growth. In doing so, it is important not to be deterred by a growing public debt and the city decision makers should not fall into the trap of implementing fiscal policies that are too tight and come at the expense of infringing on investments of "future-proofing" the city and its economy. Naturally, a balanced budget is indeed desirable and fiscal policies ought to reflect this under normal conditions and inefficient use of funds should always be combated. However, the situation following a pandemic will require immediate and special attention. Chances are that the economy will be even worse off next time a pandemic strikes without having developed a readiness for it. Finally, it can be concluded that in order for cities to become resilient, need not only be able to succeed in their rescue and recovery stages. They also need to be agile and possess the ability to re-invent themselves in response to coming pandemics/disruptions.

Action 4: Build More Urban Green Spaces

Planting more trees and forming green avenues, building parks and preserving existing green spaces and forests are important contributors to keeping a city attractive and improving the happiness and mental health of the city's denizens. In this, UGS, and "green landscaping" in general, holds great potential as a means of breathing new vibrancy and attraction into old abandoned urban areas, particularly for those cities with limited or no naturally growing vegetation.

Action 5: Plan Better Integration with Environmental Surroundings and More Aesthetically Attractive Buildings

Urbanisation that is well integrated with the natural environmental surroundings and makes good use of green spaces and water areas is appreciated by both the cities inhabitants as well those visiting the city. Buildings that are aesthetically attractive also add to the overall attractiveness of the city. Therefore, there needs to be an open dialogue and agreement between all concerned parties, such as city planners, politicians, lawmakers, architects, historians and urban conservationists etc. This could be achieved by the city authorities setting up a council, or a consultative body that would be consulted in regard to the construction/refurbishing of public buildings and/or large-scale urban development plans.

Concluding Remarks

Going forward, the main challenge for smart cities to maintain their attractiveness in light of a pandemic will be their ability to confirm the usefulness of these digital pandemic management strategies. The smart cities that succeed the best in doing this will be the ones that will remain attractive and have the best readiness for future potential pandemics.

Note

1 There is no established consensus as what years of birth constitutes Millennials and Generation Z respectively, and hence the date of birth may in some cases present an overlap for certain years, in this case for people born between 1995 and 2000.

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3 Labour

The Smart City and Pre- and Post-Pandemic Job Opportunities

1 Introduction

Job security is a concern that is shared globally and when the COVID-19 pandemic struck in the spring of 2020, the consequences were disastrous. The International Labour Organization (ILO) projected that roughly 8.8% of working hours globally (equivalent to 255 million fulltime jobs) in the second quarter of 2020 would be completely eradicated (International Labour Organization, 2021). Bankruptcies were initially estimated to increase by 26% globally during 2021, the year following the eruption of the pandemic (Gerryn, 2021). However, the outcome was, at least temporarily, mitigated to a variety of factors, including extensive government-funded stimulus money and social confinement delaying practitioners and courts from processing insolvencies in the manner they otherwise would (Miyakawa, Oikawa, & Ueda, 2021). Regardless, the pandemic left no one unaffected and the world of work may have changed forever. Many workers were laid off or furloughed, and several internationally renowned, iconic brands and companies that flourished for over a century were damaged, wiped out, or transformed as a result of the ensuing crisis, including companies from airline companies Nok Air (co-owned by Thai Airways) and Virgin Australia, to car rental pioneer Hertz and armament manufacturer Remington Outdoor Company (Tucker, 2020).

It is apparent that the pandemic fundamentally altered the premise for conducting certain types of businesses and the way in which they are done. Disruptions of this nature effectively force new businesses to find new ways to persevere and make their way into the new business climate the pandemic has lined up. Another factor to be considered is that the substitution of labour through automation etc. was already well underway prior to the pandemic eruption. As technology spreads and advances, this trend can be expected to continue globally (Seidelson, 2021; Short & Keller-Bell, 2019). Hence, this chapter will look at the likely future development of the labour market given the technological advancements and changing working conditions. While these factors often affect societies on a larger scale, it invariably follows that cities are also affected. For a more detailed discussion on what attracts

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businesses and people to cities, please see Chapter 2: *Attractiveness*. Hence, the aim of this chapter is to discuss what kind of a labour market we can expect to see in a post-pandemic future and how technology can be expected to substitute labour.

2 Changing Landscapes

2.1 Direct Pandemic Impact on the Labour Market

As the pandemic hit, people in white collar jobs were, to a wide extent, forced to start working from home, while hourly workers in sectors such as hospitality and retail were laid off or placed on furlough as business plunged (McLaughlin, 2021; Suneson, 2020). In other cases, there have been debates whether or not workspaces should be flexible with suggestions of introducing "work from anywhere" (WFA) programmes that go one step beyond and allows workers to conduct their tasks without regard to geographic proximity (Choudhury, Foroughi, & Larson, 2021). This is, of course, much dependent on the type of work on whether or not it is suitable for the nature of the task itself or for the quality of output delivered (Lund et al., 2021). The fact remains, however, that some industries were affected more severely than others.

"Default" is a financial term that denotes the failure to meet the legal obligations/conditions of a loan, and the "probability of default" (PD) is a term that describes the likelihood of such a default over a particular period of time (O'Sullivan & Sheffrin, 2001). According to an analysis conducted by the American credit rating agency Standard & Poor (S&P), the three most affected industries were airlines, restaurants and leisure facilities (Haydon, Kumar, & Bloom, 2021). S&P reported that the PD for the airline industry median peaked at 26.92% on April 2, 2020, which would render an S&P non-investment grade score of "CCC" (where "AAA" is the highest and "D" is the lowest). The airline industry's decline was, for all intents and purposes, inevitable given the enforced lockdowns and travel restrictions around the world.

Similarly, the restaurant industry's PD peaked at 19.4% (CCC) in April 2020 (Haydon & Kumar, 2020). This industry was adversely impacted by the pandemic due to mandating distancing rules curbing the number of people allowed to meet and gather in the same locality. Many cities instructed their local restaurants to switch to takeout only, which impacted millions of jobs in the restaurant sector (Suneson, 2020). As per S&P, leisure facilities' PD rose to 19.74% (CCC) at the end of March 2020 (Kumar & Haydon, 2020). This was exacerbated by the widespread closures of entertainment facilities, the postponement/cancellation of most major sporting events, as well as the implementation of social distancing measures, effectively bringing leisure facilities to a standstill. Moreover, the theatrical and home/mobile entertainment industry would change its characteristics, as cinemas and production studios temporarily closed while millions of viewers sat quarantined in their homes instead opting for digital entertainment services such as video-on-demand, streaming video and electronic sell through. To illustrate, theatrical entertainment accounted for only 15% of the total global entertainment revenue in 2020, compared to 43% in 2019, while digital media had accounted for over three-quarters of total theatrical, home/mobile entertainment revenue with a total of 1.1 billion online video subscribers in 2021, in and of itself a global increase of 26% from 2019 (Adgate, 2021; Vargas, Guerr, & Arce, 2021).

The migration to online services caused problems also to other already haemorrhaging industries. Already before the pandemic, many retailers were struggling to stay afloat. Shopping centres once towered over the cities as proud bastions of commercial activity, but in later years, an increasing number of companies found themselves challenged by online businesses. Enterprises relying on retail shops, factory production facilities or warehouses for its operations, are commonly known as "brick-and-mortar business", a term derived from earlier construction methods and used to signify the physical space and/or location that a retailer uses to sell goods and/or services (Koumbis, 2021). The businesses were badly hit when customers reduced, postponed or altogether stopped their purchases from the stores where they would normally shop. Alternatively, the supply chain caved in, with little to no possibility of finding alternative suppliers (Kuo, Ou, & Wang, 2021; Sheffi, 2020).

This development was further stressed by factors such as the global semiconductor chip shortage, which effectively held at least 169 industries hostage, in a development that was projected to persist for years (Howley, 2021; Voas, Kshetri, & DeFranco, 2021; Wu, Zhang, & Du, 2021). The shortage exemplifies one of the many indirect consequences of the COVID-19 pandemic that would become a problem than in and of itself affected the labour market and society at large. Specifically, the semiconductor chip shortage led to major queues amongst consumers for graphic cards, video game consoles, cars and other electrical devices. Even more so, it posed a serious threat to the economic post-pandemic recovery in general, but in particular, to industries such as car manufacturers who had already announced production rollbacks, with ensuing billions of dollars in expected revenue losses (Burkacky, Lingemann, & Pototzky, 2021; Li-Ying & Nell, 2020). The crisis occurred on an international scope. One of the hardest hit cities in this regard was the city in which the COVID-19 virus was originated, Wuhan, as it is also a major manufacturing centre within China where large international corporations in the auto and semiconductor industry have manufacturing sites, e.g. Foxcom, Dongfeng Motor Group, Honda and General Motors (Cai & Luo, 2020).

This crisis clearly illustrates the fragility of those supply chains and the global dependency of certain Asian cities such as China, Japan, Taiwan, South Korea and some extent even Singapore (Deloitte, 2020; Irwin-Hunt, 2021). In fact, in 2020 Asia accounted for US$305.4 billion of the global semiconductor sales, as opposed to US$94.1 billion for the US market and

US$37.3 billion for Europe (Statista, 2021). The shortage of semiconductors sent many automakers into crisis mode, and it is likely that they, along with other chipmakers will need to collaborate even more extensively in the future than before, in order to remedy the imbalance in demand (Burkacky et al., 2021; Wu et al., 2021).

Needless to say, even sectors that were not as dependent on the semiconductors were also badly struck by the pandemic, especially in those cities where people's livelihoods were already precarious. For instance, in Nairobi, Kenya, a survey in informal settlements found that 96% of those who had day-to-day incomes before the crisis went down to earning either "very little" or "nothing" (TIFA, 2020). The substantial losses in income incurred in Nairobi and in many other cities in a similar situation will, in most certainty, result in an increased urban poverty and will likely also exacerbate existing inequalities (UN-Habitat, 2021).

It should be noted that pandemic-induced job losses are likely to be higher for women compared to job losses under typical recessions (Alon, Doepke, Olmstead-Rumsey, & Tertilt, 2020; UN-Habitat, 2021). Specifically, the COVID-19 recession was called "the most unequal in modern US history" (Ettman et al., 2021, p. 502). Similar developments also occurred globally, and one of the main reasons for this was that so-called pink-collar professions were particularly affected (Bredemeier, Juessen, & Winkler, 2020; Dang & Viet Nguyen, 2021). This entails care and/or service-oriented professions traditionally dominated by women where there is a high intensity of worker–client interaction, such as jobs in the beauty industry, nursing, social work, receptionists, food and beverage services (e.g. waitresses and baristas), secretaries or childcare workers etc. (Bose & Rossi, 1983; Bredemeier et al., 2020; Tang, 2014). The situation was deemed so detrimental for this category, scientists and experts even spoke of a "pink-collar recession" (Goldblatt, 2020, p. 69; Lunnay et al., 2021, p. 2). More damning is the fact that previous "typical" recessions do not offer a good guide to what might happen to the employees in these professions once society recovers from pandemic recessions. The difference in this pandemic context is that many of these jobs may not return to their pre-crisis levels. This problem is, in turn, accentuated by the fact that skills atrophy after an extended period of absence from the workforce, and moreover, these individuals also tend to lose their habits and network (Alden & Strauss, 2016). This makes the "pink-collar" sector a particularly vulnerable labour cohort.

2.2 The Road to Recovery

As a counterpoint, there were some notable exceptions where business was actually stimulated and grew during the COVID-19 pandemic. According to a study by the Peterson Institute for International Economics, 4.4 million businesses were started by Americans during 2020, a 24% increase from 2019 and the largest documented increase on record (Brown & Crawford, 2021).

"Entrepreneurship" is here broadly defined as anything from part-time freelancers to aspiring tech billionaires, along with some businesses that are essentially side projects begun by people stuck at home during lockdown (Nummela, Paavilainen-Mäntymäki, Harikkala-Laihinen, & Raitis, 2020; United States Census Bureau, 2021). Looking at the narrower subset of "start-ups" that are likely to hire staff, the New York Times reported that there was an increase of 15.5% in the US (Casselman, 2021). This development stands apart from the overall recession brought forth by COVID-19 and also starkly contrasts the development in many other countries where start-up activities generally fell or rose only marginally and also from other previous recessions that impacted American entrepreneurship in a far more adverse manner. This has, in most part, accounted for the fact that trillions of dollars were issued in government support for US households and businesses. This is far more than was available in past recessions or in other countries and has made it possible for many of those would-be entrepreneurs to receive the funding they otherwise would not have received. However, this trend was not only present in the US, but also across many Western economies, both during and following the pandemic. For instance, France registered 84,000 new businesses in October 2020, an increase by 20% compared to October 2019 and, at the time, the highest ever recorded (De Taxis du Poët, 2021; Romei, 2020). In Germany, business registrations during late 2020 superseded that of 2019s levels, albeit after a sharp fall in the early stages of the pandemic (Romei, 2020). In Japan, 10,000 new businesses were registered in September 2020, a 14% increase compared to September 2019 (De Taxis du Poët, 2021; Romei, 2020). In the UK, business incorporations increased 30% the four weeks to mid-December 2020 compared to the same period of 2019 (Romei, 2020). In Sweden, 40,000 new businesses were started during the first half year of 2021, an increase of 9% compared to the same timeframe during 2019 (Bingström & Hammarström, 2021).

In the future, it may be possible to use machine learning to, with a >90% accuracy, predict which corporate bankruptcies that can be expected. Such tools could likely assist investors, creditors, regulators and even academics, to understand which types of businesses that are living dangerously and will allow all parties concerned to take necessary preparations ahead of time (Alam et al., 2021). However, while it may be tempting to make rash decisions based on fear, one should also take note that the pandemic impact on certain industries to a large extent appears to be transitory and potential machine learning technology will need to account for this as well. That is to say, the less of a threat a pandemic poses, the more likely the industry is to make a full recovery. For instance, as the COVID-19 vaccination programme became more widespread, the more the airline industry began recovering its losses (Cheong et al., 2021; Josephs, 2021). As a case in point, American Airlines, which had lost more than US$8.9 billion during the COVID-19 pandemic in 2020, announced it expected to reactivate most of its aircraft in the second quarter of 2021 after seeing a considerable increase in bookings that brought business back to near pre-pandemic levels (Arnold, 2021; Olaganathan, 2021). It had previously shared a US$25 billion bailout from the US treasury department in 2020 along with several other major airline companies, along with US$8 billion allotted in grants and loans for cargo carriers (Olaganathan, 2021). In Stockholm, Sweden's international airport Arlanda reported a 1,993% increase in bookings during July and August 2021, compared to that of the corresponding time period during 2020 (TT, 2021). However, some other airlines, such as Vietnam Airlines, Pacific Airlines, Vasco and Bamboo Airways, took a more opportunistic approach and increased their fees with the motivation that the move would help them improve service quality, especially the operation of the ticketing system (Nguyen, 2021).

People will always have a yearning to travel, and goods will need to be transported over long distances in speedy manner. Aircrafts currently offer the fastest, and sometimes the most viable, means of doing so. As such, the airline industry is a prime example of an industry that is likely to make a full recovery once the pandemic subsides. However, worth noting is that the closely linked tourism industry was not as swift in its recovery (Fotiadis, Polyzos, & Huan, 2021; UNWTO, 2021).

In a Swedish interview study conducted in 2020, 50 leading industrial and academic experts were asked to anticipate the future following the COVID-19 pandemic based on a "PESTEL-model", i.e. political, economic, social, technological, environmental and legal factors (Mattfolk, Holmberg, Gruvmalm, Byrge, & Edelsvärd, 2020). The experts believed that it would not be possible to return to a situation that was identical to the status quo before the pandemic eruption. While entrepreneurship in different forms will continue to be an unstoppable force, very few, if any, new businesses will be completely unaffected by the digital transformation, and even less so further into the future. The overall consensus from the experts was that the pandemic showed that societies and cities by and large coped well in regard to the accelerated speed of digital transformation. This suggests that the prospects for making certain kinds of investments into new labour markets could be less risky since it is already known that the digital transformation in and of itself is less likely to cause any insurmountable problems. Depending on the rate of recovery, the experts contended that businesses profiled towards sustainability and "upcycling" will have an advantage. Again, depending on the rate of recovery, the experts also suggested that the government should introduce some types of deductibles and or tax subsidies for businesses engaged in altruistic endeavours to mitigate the effects of COVID-19.

Some workers will engage in "occupational switching", i.e. having been placed on furlough and then discovered the possibility to switch one's line of business to something completely different, and thereby improving their own standard of living due to increased wages etc. (Lanke & Nath, 2021; Markey & Parks, 1989). However, this might not be a possibility to all workers, and some would need help to reskill. Companies offering reskilling to those that have lost their jobs could, in turn, be compensated by a reduction of the payroll taxes the companies would need to pay for each employee or a similar type of bonus to incentivise companies to reskill potential future employees. The experts also contended that the future labour market may see an increased development towards a “gig economy”. However, the issue of “gig economy” carries many implications and thus merits a wider discussion to be covered in the following section.

2.3 Gig Economy

2.3.1 The Key Significances of the Gig Economy

The issue of a “gig economy” carries many facets and is in no small part aided by the digital transformation since online platforms make freelance contracts more accessible for workers to find (Barns, 2021). It is in many ways an urban phenomenon, and several of the jobs in this sector prerequisites an urban environment such as taxi services like Uber, or food deliveries like Uber Eats etc., to name a couple of examples (Barns, 2021; Duggan, McDonnell, Sherman, & Carbery, 2022; Gottdiener, Hohle, & King, 2019). In essence, the “gig economy” denotes an alternate type of employment where individuals are not employed in the conventional sense with a fixed-term employment or a permanent contract at a particular employer. Rather, these people will work on a freelance-basis by performing a number of “gigs” for other (and not seldom multiple) contractors, hence the term “gig economy” (Larsson & Sabolová, 2020; Shibata, 2020). While the exact number is subject to definition and approximation, there were, as of 2021, an estimated 163 million freelancers, or “gig workers”, registered on online labour platforms globally (Kässi, Lehdonvirta, & Stephany, 2021). In 2015, the estimated figure was 45 million people worldwide (Gandini, 2018). To many people, the concept behind a “gig economy” caters to their desire to set their own schedule and work whenever and wherever they see fit. By the same token, it also offers contractors a way around expensive payroll insurance, employee benefits, sick leave and vacations etc. that is otherwise customary in most welfare societies. Hence, contractors need only pay for the actual work they need and whenever it is needed.

Moreover, pandemics such as COVID-19 will likely lead to the increase of “digital work” (Nagel, 2020; Neis, Butler, Shan, & Lippel, 2022). This entails assignments conducted “over the wires” and mediated through a platform, i.e. tasks that do not necessitate physical proximity between the co-workers nor a physical on-site presence in order to perform the work itself. In this, gig work offers an opportunity for a “planetary labour market”, that is to say, a labour market that is less contingent on the worker’s physical presence, but more so on his/her ability to sell their labour power using various digital platforms (Graham & Anwar, 2020; Wood, Graham, & Anwar, 2020). While the “planetary labour market” suggests an environment in which a person can, in effect, work in any city in the world while never leaving the physical bounds of their own city, digital technology has also enabled the opposite type of worker, namely those identifying as "digital nomads" (Sisson, 2017). This term denotes an individual who is not dependent on working in a traditional workplace in any one particular city, but is free to work anywhere and whenever there is access to a laptop and/or tablet computer and sufficient Internet connection (Müller, 2016). In effect, they can "work" in one city only, while physically travelling the world. Of course, digital nomads may also "work" in many different cities too while physically travelling between different cities.

As the "gig economy" offers a wide array of freelance jobs available on the online market for different professions and skillsets, it is possible to create many different short-term jobs dedicated towards a single particular task. Prior to the COVID-19 pandemic, it was estimated that 63% of all gig workers had chosen that type of employment on their own volition (Petriglieri, Ashford, & Wrzesniewski, 2018). The main incentive was that it seemingly provided the workers with the possibility of choosing their own projects and setting their own schedule (Larsson & Sabolová, 2020; Petriglieri et al., 2018). In theory, the "gig economy" allow individuals to pick up temporary jobs in any city across the world. However, the number of individuals engaging in "gig work" varies immensely depending on geographical region. For example, it was estimated that roughly 25% of all employees in the United States would be working remotely, with 36.2 million Americans projected to be working remotely by 2025, an 87% increase from pre-pandemic levels (Kreamer, Stock, & Rogelberg, 2021). Similar trends are expected around the world where people have been working remotely to an increasing extent. Given this development, and that an increasing number of employers are comfortable having their work conducted remotely, it would seem plausible that there would likely be an increase in enlisting gig workers to fill talent gaps. Another issue is, of course, what the market can bear, and where the greatest amount of productivity is met, as some other studies have purported that workers put in more hours while working from home while producing somewhat less output (Gibbs, Mengel, & Siemroth, 2021).

2.3.2 The Grievances against the Gig Economy

Nevertheless, the perceived freedom of a gig worker may also come at a high cost. The freelancers are expected to consistently be on top of their game, often with higher expectations on delivery than from a "regular employee" (Petriglieri et al., 2018). For many workers, keeping one's level of productivity at constant top capacity is a struggle that entails long working hours (Sinicki, 2018). The flipside is that over time, working under such conditions may erode one's level of productivity and it may lead to detrimental health issues along the way. This leads to a vicious circle where the gig worker is less productive due to stress and/or illness, but still has to compensate by putting in more hours to make up for lost productivity, which worsens the stress and/or illness (Larsson & Sabolová, 2020). Some reports have suggested that the stress levels gig workers experience may lead to an increase of cardiovascular diseases and even cancer (Bolino, Kelemen, & Matthews, 2021; Freni-Sterrantino & Salerno, 2021; Tran & Sokas, 2017). Moreover, a 2019 study by the American Heart Association indicates that those working long hours (more than 10 hours per day for at least 50 days a year) may run a 29–45% greater risk of stroke (Fadel et al., 2019).

In addition, a major and often overlooked consequence of the "gig economy" is the increasing number of people who will be without legislative protection. This means that gig workers will likely need some kind of insurance coverage as the welfare system (which exists to varying degrees in different countries) may not always provide the necessary healthcare benefits for the gig workers (Larsson & Sabolová, 2020). Ironically, gig workers are twice as likely as permanent employees to lack traditional health insurance (Foroohar, 2019; Larsson & Sabolová, 2020).

2.3.3 The Legal and Political Complexities of the Gig Economy

A long-standing question has been whether gig workers are actually employed workers or if they are self-employed (Todolí-Signes, 2017). This is a vital distinction that determines whether or not a worker is entitled to holiday pay, sick leave, possible minimum wage etc. Hence, there needs to be clear legislation in places that makes it clear which of the two aforementioned categories should cover "gig work". There also needs to be clearly defined regulations pertaining to liability insurances, and whether the contractor or the gig worker should be the ones responsible for making sure such are in place. For this reason, there needs to be a thorough review to scrutinise the insurances available to freelancers to ensure that the terms are reasonable and fair and that potential legislative loopholes that do exist in this space must be remedied.

Some cities have tried to address this complex situation. For instance, New York City is a city that makes extensive use of gig workers and avails itself to offer better legal protection to its freelance works than many other cities around the world (Rosenfeld, 2021). On May 15, 2017, the city implemented "Local Law 140 of 2016", commonly known as the "Freelance Isn't Free Act", which stipulates that gig workers in a timely fashion will need to be presented with a written contract and receive full payment along with an added protection from any potential retaliatory acts from the employee for having received these rights (Baranowski, 2018; Marius, 2021). While this may seem reasonable, and even self-evident to many who have held a "regular" employment, additional attempts at legislation seeking to grant gig workers with more rights have been met with fierce opposition. For instance, in 2019, New York state Senator Diane Savino (D-Staten Island/Brooklyn) and then-Assembly Member Marcos Crespo introduced a bill that would have allowed gig workers like Uber drivers and Postmates delivery workers to unionise, which would, in turn, have created a new employment category that was neither "employee" nor "independent contractor" (McDonough, 2021). However, the proposal would cause indignation among both labour unions and tech companies and would ultimately fail to advance.

A similar proposal was drafted two years later (yet again by state Sen. Savino), however, this time, it also drew the ire from the Transport Workers Union as well (which had initially supported it) since the draft bill would entail that the freelancers would concede certain rights already from the get-go (Dubal, 2022; Lew, Chatterjee, & Torres, 2021). Specifically, unions would be prohibited from issuing strikes or demonstrations against an employer, under what was known as a "labor peace agreement" (Estlund & Liebman, 2022, p. 399). Another provision would forbid local governments from creating a minimum wage for freelancers or the app industry, as well as barring any local taxes, fees or surcharges. Support for the bill continued to dwindle and in June 2021, state Sen. Savino would eventually scrap the bill altogether (Dubal, 2022; Eidelson, 2021). To this end, the gig economy remains a complex area with many lingering teething problems in regard to labour law and social security.

2.3.4 Affordances and Constraints

Then what affordances and constraints does a post-pandemic gig economy proffer, and to whom? As mentioned earlier in this chapter, prior to the COVID-19 pandemic, the "gig economy" was on the rise (Gandini, 2018). The consequences of the pandemic on the one hand, is that employers' attitude towards remote working has changed and many people have been able to work remotely even with a traditional employment in ways that may not have been possible before. For the category of people that are primarily motivated by the prospects of being able to work remotely, it is likely that the incentive to work in a gig-based economy has lessened. Also, the gig economy enables people to travel to different cities to try out different assignments. The travel restrictions and decreased job opportunities brought on by the pandemic would, of course, also have a stymieing effect on this category of gig workers, at least for those seeking to work in different cities in the physical sense. On the other hand, gig economy-based jobs may also seem palatable for struggling business owners who can only hire certain employees on a freelance-basis. Also, once the effect of a pandemic subsides, the status quo that was before begins to return, which would likely also mean the same regarding the development of the gig economy.

Notwithstanding, the "gig economy" can only find sustenance for as long as there are enough people to utilise it. National and/or city authorities may affect the course of the gig economy to some degree by implementing added taxation on actors seeking to enlist "gig worker", which, in turn, may have a supressing effect on the wider spread of the "gig economy". Nevertheless, it is paramount that citizens are educated and properly informed about what it means to be a "gig worker" so that they are able to make an informed decision of whether or not to pursue this work format. That is not to say that the "gig economy" in its current format does not provide for optimal solutions for certain types of people. People looking for a part-time job, or for an extra job on the side of their regular employment during the odd hours, for example, may find that the "gig economy" is able to provide them with a solid opportunity (Ravenelle, 2019; Sinicki, 2018).

2.4 Substitution of Labour

2.4.1 Automation vs. Mechanisation

Naturally, virtually all industries are impacted by global pandemics in one way or another. However, some alterations are not necessarily a direct consequence by the pandemic in and of itself. In some cases, it is digital technology that is pushing for a certain type of development that will gradually impact/transform the labour market. The pandemic response of increased digitalisation may, in these cases, propel the development, possibly accelerating the development in certain cases by several years (OECD, 2020a).

As technology advances, different modes of labour are made redundant due to the possibility of their substitution by machines, or "automation" (Levy & Murnane, 2004). The concept of "automation" entails a process in which technology is introduced to automatically carry out a task previously performed by a human/animal, or alternatively one that has hitherto been impossible to perform by human hands (Hussain, 2010). The term "automation" is sometimes erroneously used interchangeably with the closely related concept of "mechanisation", which entails the replacement of human labour by machines (Gupta & Arora, 2013). The main distinction between the two is that mechanisation merely entails replacing human labour with machines while automation replaces human control with machines. Thus, mechanisation would still require human participation to provide information or instruction. Nevertheless, both concepts are generally covered by the term "substitution of labour" (Van der Zande, Teigland, Siri, & Teigland, 2020).

2.4.2 The Different Types of Tasks

Some jobs contain tasks that can already be automated while others cannot. For that reason, it is important to understand which tasks are substitutable (substitution potential) before considering the overall societal effect of the substitution of labour (Autor, Levy, & Murnane, 2003). Essentially, labour can be conceptualised as a series of tasks, or sequences, rather than in terms of "complete jobs". Specifically, there is a distinction between "routine" tasks and "non-routine" tasks on the one hand, and "manual" and "cognitive" tasks on the other hand, as illustrated in Figure 3.1 (Van der Zande et al., 2020, p. 48).

	Cognitive	Manual
Routine	Explicit rules Mental processes	Explicit rules Motor skills
Non-routine	Rules difficult to codify Mental processes	Rules difficult to codify Motor skills

Figure 3.1 Four categories of job tasks. Adapted from Van der Zande et al. (2020, p. 48).

Routine tasks are the type of tasks that adhere to defined, explicit rules, and thus possible to "codify". Jobs in this category also tend to have lower wages in cities (Andersson, Klaesson, & Larsson, 2014). Non-routine tasks do not follow any particular linear sequence, which makes them considerably more difficult to code. It thus follows that routine tasks are, as a general rule, more easily substitutable by technology while non-routine tasks are less likely to be substituted by digital technology. By the same token, manual tasks refer to physical activities that necessitate mobility and motor skills, while cognitive tasks pertain to mental processes. These are described in more detail below.

2.4.3 Routine Manual Tasks

A "routine manual" task entails one that includes physical activities requiring systematic repetition of a consistent procedure. The main capabilities needed to carry out these tasks are gross and fine motor skills, sensory perception, and, in some cases, mobility. Examples of such tasks include assembling, picking and sorting, welding and cooking (Van der Zande et al., 2020). The agricultural sector and the car manufacturing industries have seen many processes automated throughout the years. In recent years, advances in sensory perception and manual dexterity have enabled robots to perform duties requiring higher degrees of precision, such as slicing meat, assembling customised orders, manufacturing electronic components (Sander & Wolfgang, 2014; Van der Zande et al., 2020). This is a development that was further escalated due to the COVID-19 pandemic since social distancing requirements disrupted the layout of processing and packaging lines, prompting more automation (Bunge & Newman, 2020; Hailu, 2021; Hobbs, 2021). This, in turn, also affected workers handling warehousing applications, e.g. bin picking and/or delivery to workstations etc.

Automated robots have also been increasing their presence in the service industry, where they are able to perform various tasks such cleaning and delivery etc. For example, in Nagasaki, Japan, the Henn-na Hotel (opened in 2015) is recognised by Guinness World Records as the first robot-staffed hotel (Choi, Choi, Oh, & Kim, 2020; Reis, Melão, Salvadorinho, Soares, & Rosete, 2020).

The hotel utilises anthropomorphic dinosaur animatronics in the place of various human staff services, including the front desk, butler services, housekeeping and the concierge (Choi et al., 2020). Another example is Hotel JEN Singapore Tanglin by Shangri-La in Singapore, which in 2017, introduced two relay robots (an autonomous delivery robot that works in hotels, hospitals and other public spaces) named “Jeno” and “Jena” to deliver desired amenities and local delights from the in-room dining menu to the hotel guests round the clock (Choi et al., 2020; Knapp, Zeratsky, & Kowitz, 2016) (Figure 3.2).

Given the linearity and predictability of “routine manual” tasks, they are easily codified and digitalised. Already now, these tasks have largely been substituted by technology in some form or another and the technology to do this exists at a mature, and advanced level, particularly for gross motor skills, where technology has long since been outperforming humans. For this reason, this category is the most likely to become substituted by digital technology, to the extent that it has not already happened (Autor et al., 2003; Van der Zande et al., 2020). In fact, it is anticipated that in the US, as much as 81% of these tasks are bound for labour substitution (Estlund, 2018; Manyika et al., 2017; Van der Zande et al., 2020).

With advances in sensors and increasing robot dexterity, and an increased pandemic awareness, more high-precision tasks will undoubtedly become candidates for substitution and one can expect to see more developments rolled out in different cities within the next decade or so, with one prime candidate being manufacturing tasks in the electronics sector (Van der Zande et al.,

Figure 3.2 Jena, the hotel delivery robot.
Source: JEN Singapore Tanglin by Shangri-La.

2020). However, additional engineering advances will be needed in order to increase the flexibility of robotic systems by decreasing the reconfiguration time (Robotics Technology Consortium, 2020; Van der Zande et al., 2020).

2.4.4 Non-Routine Manual Tasks

A "non-routine manual" task is characterised by non-structured physical tasks occurring in unpredictable environments, usually necessitating situational adaptability and in-person interaction. These tasks need capabilities like sensory perception, fine and gross motor skills, social and emotional capabilities, natural language processing, navigation and mobility (Van der Zande et al., 2020). For the most part, these capabilities cannot yet be automated in a way that supersedes a human level of performance and a major challenge for automation involves the level of flexibility the machines would need to account for (Autor, 2015; Frank, Yang, & Frenette, 2021). For this reason, the level of automation in this category remains low at merely 26% (Manyika et al., 2017). This includes various tasks such as operating cranes, surgical assistance with surgery, lorry driving, bedmaking and janitorial duties etc. (Nokelainen, Nevalainen, & Niemi, 2018; Van der Zande et al., 2020).

However, technological developments in machine learning and sensory perception as well as improved physical capabilities have enabled smart technology to assume an increasing number of manual non-routine tasks. For instance, advances in sensor technology and manual dexterity enable robots to conduct high precision, non-standardised tasks. Examples include the development of autonomous fruit and vegetable harvester robots that are able to clamp and cut the peduncles (stalk) of crops without contacting the flesh or mesocarp (Zhang et al., 2020).

While mechanisation is very much a part of the "non-routine manual" tasks, automation occurs in more isolated instances and while more processes will undoubtedly be substituted as technology advances, jobs in this categories will be less affected for the foreseeable future, even if certain elements of those jobs may change. This is in no small part, due to the fact that many of the processes require human interaction and this would necessitate an exceptionally advanced language recognition system along with social and emotional capabilities, as well as user interfaces. For instance, a nurse tending to a patient may involve multiple steps calling for human interaction. The nurse would perhaps need to walk the patient down the hallway, help the patient in or out of bed, during which point the nurse would have to be able to determine the patient's emotional/psychological state of mind by interacting with him/her, while also possessing fine motor skills to know where to hold and/or touch the patient and know how much force to apply and so forth (Van der Zande et al., 2020). Given the multitude of smaller tasks involved in the overarching task of tending to the patient, and the requirement each of these places on the human condition, it is unlikely that such tasks could become automated in any foreseeable future.

2.4.5 Routine Cognitive Tasks

"Routine cognitive" tasks entail mental (i.e. non-physical) tasks that replicate a particular procedure in a predictable environment. For the most part, this pertains to various aspects of processing structured information, i.e. data collection, organisation and storage (Autor et al., 2003). The required capabilities for such tasks are retrieving information, recognising known patterns, optimising and planning, logical reasoning/problem solving, and natural language processing (Van der Zande et al., 2020).

This often consists of data processing tasks e.g. calculating and bookkeeping. It can also include more "front office"-based tasks that necessitate customer interaction such as cashiers, telephone operators, bank tellers and so forth. Because these tasks are characterised by a fairly predictable pattern with set routines, they have a high likelihood of being substituted by machines in the future, with an estimated future substitution rate in the US ranging from 64% for tasks concerning data collection to 69% for tasks pertaining to data processing (Manyika et al., 2017). Already today, many processes have been automated that involve administrative tasks, bookkeeping, invoicing, optimising resource need and so forth (Acemoglu & Autor, 2011; Van der Zande et al., 2020).

Whether or not more data collection and data processing tasks can and/or will be automated in the near future largely depends on the pace of digitalisation. Along with COVID-19, the incentive to digitalise has markedly increased (Giordani & Rullani, 2020; Mutanov & Zhuparova, 2021). As the digital transformation accelerates, the step to automation of processes and data will be nearer. To this end, the automation of front office services will invariably hinge on the digital technology's ability to interact with customers in a way that is accurate, efficient and satisfactory. This means that technological developments in natural language processing and emotional capabilities will likely determine the rate of which we can expect to see automation of these tasks.

2.4.6 Non-Routine Cognitive Tasks

"Non-routine cognitive" tasks refer to mental (non-physical/abstract) tasks that do not follow a structured procedure and/or take place in unpredictable environments (Autor et al., 2003; Van der Zande et al., 2020). These types of tasks necessitate multiple cognitive capabilities, such as creativity, logical reasoning, generating novel patterns and coordination with multiple agents (Van der Zande et al., 2020). As such, natural language processing and social and emotional capabilities are generally important components to carry out these tasks (Acemoglu & Autor, 2011). Typical "non-routine cognitive" activities include those that seek to involve stakeholder interaction, team leading, management and managing and developing others, writing legal documents, negotiations, teaching, diagnosing diseases and so forth (Van der Zande et al., 2020). "Non-routine cognitive" tasks employ often high-skilled individuals such as corporate managers, science professionals, pharmacologists and architects, etc. (Bussolo et al., 2020; Harmon, 2018). Moreover, cognitive and social jobs are overrepresented in city economies and they tend to have much higher urban wage premia, particularly for so-called white collar jobs (Bacolod, Blum, & Strange, 2009; Gould, 2007).

The rate of labour substitution for this category has generally been fairly low, approximately 20% or somewhat less (Manyika et al., 2017). The main reason for this is that these tasks have thus far been difficult to automate. Inherently, mankind has, for a long time, held an advantage over machines in three distinct areas, namely: (1) high-end creativity, (2) emotions and interpersonal relations, and (3) dexterity and mobility (Bernstein & Raman, 2015). However, in the future, this will likely change. The availability of big data along with recent advances in machine learning (most notably so in pattern recognition and language recognition) means that there is a greater potential for machines to take on unstructured tasks (Ashford & Hall, 2019; Sumer, 2018). By applying unsupervised learning, a digital device can generate its own structure in an unstructured environment. Already now, machine learning technology can be used to detect fraud (Sadgali, Saael, & Benabbou, 2019). By building models based on past transactions, social network information and other external sources of information, the computer can apply pattern recognition in order to pick up on various anomalies, exceptions and/or outliers, which, in turn, means that fraudulent behaviour is many times detectable without the need of direct human interaction (Wellers, Elliott, & Noga, 2017). Machine learning is also used for various tasks in the legal domain, in terms of scanning and processing vast numbers of legal documents in a quick and efficient manner, while presenting the results graphically in a clear and perspicuous manner to the legal staff members (Van der Zande et al., 2020). Nevertheless, the rate at which "non-routine cognitive" tasks can be automated will likely remain on a smaller scale for the foreseeable future. At least until machine learning has reached the level of maturity in which it is able to outperform humans in the three aforementioned district areas of cognitive, social and emotional capabilities while also ensuring that there is a way to automatically retrieve enough data for each specific cognitive non-routine task that is needed (Van der Zande et al., 2020). The challenge herein lies in the fact that "non-routine" task data alternates from case to case and pattern recognition cannot be utilised without a frame of reference.

2.4.7 The Future Ramifications of Labour Automation

Digital technology is able to automate an ever-increasing number of tasks, particularly, if they are based on "routine". Bringing automation and robotisation of "non-routine" tasks to the next level would require fundamental advances in technology, especially in regard to language processing capabilities. While a technological revolution of that magnitude should not be expected in this area within the next few years, it is likely that we will see an increasingly gradual development in which task by task becomes automated either partially or in its entirety. Regardless, human involvement will still most certainly be required in some form, shape or manner. On the other hand, the potential for substituting routine tasks is high and one can expect automation to continue as along as technology advances and matures enough to be applied in these areas. An illustration of job task categories and their substitution rate can be seen in Figure 3.3 (Van der Zande et al., 2020, p. 54).

What is important to remember is that innovation is positively correlated with social mobility (Gedikli & Derindağ, 2021). This means that in those cities in which there is a larger degree of automation of the labour market, one can also expect to see a larger degree of non-routine cognitive-based jobs as automation and robotic applications require tasks of high-skilled professionals e.g. engineers, software developers and managers (Acemoglu & Autor, 2011). By the same token, automation, along with globalisation (mainly due to offshoring middle-skill parts manufacturing, particularly to China), also risks creating employment polarisation in the cities, both in the developed countries and the developing countries, where the share of middle-skilled

	Cognitive	**Manual**
Routine	***Primary Required Capabilities*** Retrieving information Recognising known patterns Optimising and planning Logical reasoning/problem solving Natural language processing ***Examples*** Data processing tasks, e.g. calculating and bookkeeping Customer service tasks by e.g. cashiers, telephone operators, bank tellers **Predicted Substitution Rate: 64/69%***	***Primary Required Capabilities*** Gross and fine motor skills Sensory perception Mobility to some extent ***Example*** Assembling Picking and sorting Welding Cooking **Predicted Substitution Rate: 81%**
Non-routine	***Primary Required Capabilities*** Creativity Logical reasoning/problem solving Generating novel patterns Coordinating with multiple agents Natural language processing Social and emotional capabilities ***Examples*** Legal writing Negotiating Teaching Diagnosing diseases **Predicted Substitution Rate: <20%**	***Primary Required Capabilities*** Fine and gross motor skills Sensory perception Social and emotional capabilities Natural language processing Navigation Mobility ***Examples*** Crane operation Surgical assistance Janitorial duties Bedmaking **Predicted Substitution Rate: 26%**

* 64% refers to tasks concerning data collection. 69% refers to tasks pertaining to data processing.

Figure 3.3 Summary of required capabilities, sample tasks and predicted substitution rate in the US for each job task category

Source: Van der Zande, Teigland, Siri, & Teigland, 2020, p. 54.

jobs is on a steady decline (Kopf, 2017; OECD, 2020b; Peugny, 2019). At this point, there are essentially two different routes to which one may respond to the situation. On the one hand, one may opt for a more "protectionistic" approach in which one seeks to regulate, or rather curb, offshore outsourcing by means of legislation to ensure that the tasks are performed in the home cities by local talent, if possible. The other route is to ensure that there is a general safety net in place for workers that will provide support in the event of outsourcing and/or offshoring. Such a safety net would safeguard the protection of those workers made redundant, while also allowing the jobs to be carried out more cost-efficiently elsewhere.

"Middle-skilled" jobs employed 37.7 million workers in the US as of 2015 and among its professions, many may find jobs such as clerical, sales, construction, installation/repair, production and transportation/material moving occupational groupings (Modestino, 2016). The consequence is that the middle-skilled workers will need to upgrade their skillsets wherever possible but notwithstanding, the job polarisation between low-skilled workers and high-skilled workers will become a reality for most cities with a high degree of automation (Peugny, 2019). For many of those middle-skilled workers unable, or unwilling to reskill, the only remaining options short of unemployment will be to try and "stem the tide" by moving to another less automated city, picking up gig work, submit to occupational downgrading or to be forced to accept more precarious labour conditions for the few remaining jobs in their professional category.

On the other hand, other research indicates that the decimation of middle-skilled jobs may be tapering off in the future (Autor, 2015; Van der Zande et al., 2020). This is, in part, due to the fact that many of the middle-skilled jobs that will be left remaining will need a combination of "non-routine" characteristics, such as emotional abilities, problem-solving, as well as a level of flexibility that is not yet possible to automate. Another reason is that the rise of new technologies has created a market for many other types of middle-skilled jobs. This includes healthcare technicians and proprietors of eateries etc. that rely on technology in a non-specialised fashion, but who are needed "on-site" regardless in order to operate and/or interpret the machines and the data they produce. (Van der Zande et al., 2020).

In other areas, automation will lead to human staff being able to spend more time on complementary duties where they hold a comparative advantage, i.e. tasks that necessitate creativity and human interaction (Autor, 2015; Van der Zande et al., 2020). In many cases, one can expect to see a greater level of integration between technology and humans, where, for instance, a human expert, such as a medical surgeon, will remain responsible for diagnosing a patient, but may draw inferences and insights from expertise given to him/her by means of AI (International Federation of Robotics, 2017; Van der Zande et al., 2020). Another example would be equipping drones with automated external defibrillators (AED), which could then be dispatched to assist in medical emergencies before paramedics are able to reach the scene (Figure 3.4).

Figure 3.4 Drone with an automated external defibrillator (AED) on the way to a person suffering cardiac arrest.
Source: Everdrone.

3 Barriers against Automation

One of the chief barriers against automation by and large, is the trust factor (Spain & Madhavan, 2009). Already now, "smart technology" is used to make a variety of different societal functions more effective across different cities, including everything from border administration and law enforcement insurance claims processing. However, the expansion of automated processes is only possible, if society permits it and if there is a general social acceptance. It also follows that there must be trust and confidence in whatever regulatory systems set in place to monitor the automated technologies (Manyika et al., 2017). In addition, there must be a clear sense of accountability in the event that something goes awry, a matter that could be especially problematic in the event of human-automated joint tasks (Salehi, Chiou, & Wilkins, 2018).

By the same token, securing societal acceptance of automation technology has been something of a paradox, for why would people embrace a technology that will eventually seek to put them out of a job? In addressing this concern, one may add that it is, in many cases, a matter of automating processes within a job rather than the entire job itself, and thus there will still be a need for human labour, particularly in the non-routine oriented job sectors. There is, however, a risk that various actors will use the COVID-19 pandemic and the need for social distancing etc. as a pretext to automate a multitude of processes in a much more rapid manner than would have been possible in a point in time that was not plagued by a pandemic.

4 Conclusion

The aim of this chapter was to discuss what kind of a labour market we can expect to see in a post-pandemic future and how technology can be expected to substitute labour.

Action 1: Offer Support to Those Who Offer Reskilling

It is important to remember that while pandemics affect the labour market across a multitude of industries to various degrees, the effects carry different levels of impact. In some cases, the effects are more temporary/transitory, where the situation can be expected to recover and largely return to the status quo that was before the pandemic. In other cases, the effects are more lasting, and in other cases, the effects (be they direct or indirect) are likely to completely upend the enterprise and/or practice as we know them. Sometimes, businesses that have previously co-varied with one another will likely be out of synch, at least for a while. An example of this is the airline industry, which will most certainly recover much sooner than the tourism industry.

For the less fortunate industries, many people will be forced to reskill and enter a new industry, perhaps only short-term until their original business picks up again, or perhaps indefinitely. Regardless, companies and entrepreneurs offering reskilling need to receive some form of relief from the government. This could, for instance, be in the form of a reduction of the payroll taxes they would need to pay for each employee, or possibly a bonus or subvention in order to incentivise the reskilling of more labour and potential future employees.

Another example can be taken from Indonesia, where the government has presented the introduction of advanced technical and vocational education through a referred to as a "Revitalisation Program for Vocational Higher Education Institutions" (Fairman, Voak, Abdullah, & Indarjo, 2019, p. 4). The aim of this programme is to improve the relevance, engagement and understanding between vocational and higher education institutions with business and industry, although it will regularly call on international educational support.

Action 2: Adopt a Flexible and Pragmatic Attitude towards Workspace Even for Post-Pandemic Era

The pandemic illustrated that, at least in the short run, many businesses and tasks managed to stay operational even if the job tasks were conducted remotely. In many cases, the greatest obstacle to remote work has been for traditional and attitudinal reasons rather than for physical or practical reasons. Along with the changing work conditions, habits and preferences also change, with many people getting accustomed to remote work. Some people may even find that they are more productive and energetic while working from home given the fact that there is no more travelling time to the workplace involved. By the same token, social interaction remains important in order to foster an organisational culture and physical, in-person meetings may not always be substitutable via digital conferencing.

Notwithstanding, organisations should not completely discontinue the work-from-home practices that have been set in place even after the pandemic has passed. Indeed, working from home come with both positive and impeding consequences (Galanti, Guidetti, Mazzei, Zappalà, & Toscano, 2021). Admittedly, working remotely is, and will remain, a polarising issue in which some people will adamantly defend the need to be physically present at the office at set times, while others will favour anything from more flexibility to a total reimaging of the workplace, such as a WFA policy. In this regard, there have been reports of a 4.4% increase in output for the WFA programmes, but naturally, the results will likely vary depending on the type of job (Choudhury et al., 2021). Nevertheless, companies will need to be less dogmatic and rather take in a flexible and pragmatic approach to the workspace situation so that it fosters operability, staff well-being and output. For instance, if the staff requests it, and the output is not adversely impacted, a company could provide the staff with the option of working remotely at least few days a week whenever and wherever possible.

Action 3: Provide a Clear Legal Definition and a Community of Practice of the "Gig Economy"

The "gig economy" was spreading even before the pandemic and will likely continue to do so even in a post-pandemic world. However, there needs to be a clearer legal definition identifying the role of "gig workers". If deemed to be "self-employees", it follows that these workers should also be entitled to the same legal status (including tax deductions and other benefits). Conversely, if they are deemed to be employees, the social net and welfare benefits that follow should be applied as well.

Once a clear definition is made, other practical issues pertaining to labour law will need to be tethered out, and social partners among the "gig economy" would need to be established so that a community of practice could be established. By doing so, people could make their own informed decisions about the "rules of the game" and as to whether or not the "gig economy" is a type of work that caters to their interests and needs. Freelancers needing to support themselves on a fulltime basis will need to work under clearly defined conditions in order to avoid slipping through the cracks. By establishing a community of practice, along with a clear legal framework and fair standards (corresponding to those of other average workers in the same business), it is possible to ensure not only the well-being of the individual but also the well-being of companies in order to maintain consistently high worker productivity.

Action 4: Address the Plight of the Middle-Skilled Routine Workers

Automation provides a means of creating a safer environment for certain groups of workers during times of pandemics and calls for social distancing. Nevertheless, the automation potential for "non-routine" tasks remains limited, particularly for tasks concerning autonomous mobility, creativity, problem solving and complex communication.

Regardless, it is mainly the middle-skilled jobs that are placed at the front line of labour substitution as automation technology advances. Acutely, this pertains particularly to those middle-skilled workers in the routine-based professions, who will need help to reskill to either non-routine-based middle-skill jobs, or to cognitive non-routine-based jobs. In a longer perspective, all workers in routine-based jobs not relying on mobility and/or human interaction would also require help with reskilling. For this reason, there needs to be a general safety net in place for workers to provide them with the necessary support in the event of job redundancy and during the time they need to reskill.

Action 5: Build Societal Trust in Automation

Trust remains a critical component as to whether or not something is accepted by society. A pandemic may provide organisations with a window of opportunity to hasten far-reaching transformative automation reforms in their businesses, but there may be a post-pandemic backlash from society at large, if processes and technologies are introduced that are deemed to be unreliable, dangerous and/or hostile. One of the chief components in this is to ensure that there is clearly defined accountability set in place that stipulates who is responsible for what parts of the machines and under what circumstances.

Another important part is ensuring that the automation of technologies is exhaustively integrated inasmuch that the interaction between smart technology and humans feels natural and real. This is in part done not only through the advancement of technology but also through gradually phasing in the new technology and fine-tuning it along the way, in an ongoing dialogue with the people who are affected by the robots and interact with them.

Concluding Remarks

Technology and pandemics change the labour market in their own different ways. The covariance of which, however may cause the changes to occur far more rapidly and in a less controlled manner as well as somewhat different than originally anticipated. Technology can help build resilience in the sense that it protects people from hazardous tasks, while at the same time keeping operations going. However, there is more to the future of labour than mere automation, as so much concerning the format of how we conduct labour is changing as well, including from where we work and under what terms and conditions we work etc.

The future, post-pandemic developments on the labour market is in many ways an iterative process in which it is only possible to learn the true outcome through repeated evaluations and fine-tuning of each implemented change and/or innovation. For this reason, it will, on a regulatory level, be necessary to ensure that there is a system of necessary checks-and-balances along with a clear sense of accountability, in order to build the societal trust that is needed in order to safeguard a successful digital transformation of labour. The substitution of labour along with the changing working conditions, affects everyone active in the workforce, and must be broached by politicians and policymakers in order to ensure that the labour market is resilient and sustainable, not only during the ongoing pandemic, but also once it has passed.

Of course, additional research is required to assess issues such as the opportunity costs of reskilling workers, the effects on productivity and morale in adopting a work culture in which the regular office place is shared with the "home office", the consequences of the gig economy and any number of ethical and/or political ramifications associated to this development. For this reason, a serious and widespread intellectual debate on the future of labour is needed and what could or should be done to address the future developments.

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4 Housing

Past and Future Living

1 Introduction

For centuries, domestic architecture has been the hallmark how certain types of families and/or social lives should be promoted and the types of individuals one wishes to attract (Wright, 1981). Put differently, "the production of the built form, in whatever time or place, in whatever shape and for whatever purpose, is irrevocably a human and a social act" (Franklin, 2006, p. 1). This means that wherever and however people have chosen to live, temporally and geographically, it has been a reflection on that society's way of life and the things that are important to that society. Modern societies are characterised by technological advancements as well as clustering and/or agglomeration, which has fuelled the expansion of cities. It was arguably during the seventeenth century when the image of a city fully developed in alignment with technological development first emerged (Cugurullo, 2019). Francis Bacon's (1561–1626) incomplete and posthumously published novel *New Atlantis* envisions the idea of an island-city called "Bensalem" controlled by a community of scientists (Bacon, 1626). These scientists were, in turn, working for a state-sponsored scientific institution known as "Salomon's House", effectively a type of modern research university specialising in both applied and pure sciences (Willes, 2017). The inhabitants, in turn, are characterised by qualities such as generosity, enlightenment, dignity, splendour, piety and public spirit. Bacon's narrative depicts Bensalem as a large living laboratory in which the members of Salomon's House pursue a never-ending stream of technological innovation.

Among the creations envisioned by Bacon, one finds pre-modern types of transportation such as submarines and aircraft, in addition to robots. Although a work of fiction, Bacon's notion of New Atlantis and the linkage between technological development and urban development is known to have carried a considerable impact on the medieval conception of what a future urban perspective could look like (Cugurullo, 2019). Since then, Bacon's premonition of the techno-urban development has been a recurring theme through many works of fiction and futures studies in regard to the evolution of cities. In many ways, the "smart city" embodies the principal vision set

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forth by Bacon (and many others after him). By agglomerating competency and utilising technological advancements, we are able to exalt our cities and bring out societies to higher level.

It is this potential of agglomerating competency that makes cities such successful greenhouses of ideas, innovation, entrepreneurship and economic (Marshall, 1890). When specialised firms, and more importantly, skilled individuals cluster together, there are opportunities for "knowledge spill-overs" that encourages innovation, entrepreneurship and over time enhances the opportunities for growth (Henderson, 2007; Hörte, 2004). Agglomeration is in its nature conditioned upon density. However, density does not only encourage knowledge spill-over, but also viral infections. This is a reason why cities throughout history have been prone to generate productive ideas as well as pandemics. The aim of this chapter is thus to explore how smart homes can be improved in the future and how smart city housing can be ensured in the future while mitigating the problem of overcrowding and subsequently, the risk of further pandemic spread.

2 History of Housing

Throughout the ages, housing has taken on many shapes, forms and sizes. In early, pre-urban history, housing mainly consisted of rudimentary dwellings shaped by the constraints of their environments. Many times, similar housing arrangements could be found across civilisations separated over vast distances across the lands and geographic regions. These similarities were seemingly the result of these different civilisations sharing the same set of heritage, influences, and/or circumstances (Centers for Disease Control and Prevention and U.S. Department of Housing and Urban Development, 2006). The prehistoric man would often dwell in caves. This was mostly out of convenience as caves were readily available and rarely required any additional construction work. In areas where there were no caves, humans were forced to construct shelters. This forced them, to the best of their ability, to build shelters that fitted their needs according to whatever available resources they had at their disposal (Schoenauer, 2000).

In contrast, transient dwellings, or "ephemeral dwellings", were characteristic of the nomadic people, such as hunter-gatherer groups as the "Bushmen" (San peoples) of Southern Africa; and the aborigines of Australia, who would traverse the lands from one day to the next in the search for food (Schoenauer, 2000; Shirwani, Kamran, & Malik, 2019).

Similarly, "episodic housing" was characterised by the Inuit igloo, the tents of the Tungus of eastern Siberia, and the Sámi tents of northern Europe (Scott, Bowman, Bond, Pyne, & Alexander, 2014). Episodic housing was aimed to provide dwelling for a limited period, usually consisting of a few weeks. This type of housing tended to be constructed in a more communal fashion and would this have a greater impact on the surrounding environment due to the application of a "slash-and-burn" agriculture (Kettler, 1996). This was a farming technique that involved the cutting and burning of plants in a forest or woodland to create a field known as a "swidden". The "swidden" would consist of nutrient-rich layer of ash, making the soil fertile (D. Das, 2018).

Another type of housing was the "periodic dwellings", which were by definition also a type of temporary dwelling, albeit on a more regular basis. This was primarily the choice of dwelling by many nomadic tribal societies living in a "pastoral economy", meaning that the livestock farmer had some form of ownership of the land used (Centers for Disease Control and Prevention and U.S. Department of Housing and Urban Development, 2006). Typical examples of this type of housing are the "yurt" (a portable, round tent covered with skins or felt) used by nomadic groups in the steppes of Central Asia (predominantly Mongolian and Kirgizian groups) (Gardner & Burentogtokh, 2018; Shirwani et al., 2019). The "yurt" carries a particularly important significance to history of the Turkic peoples as it literally translates to "tent", i.e. denoting a "home", or more specifically, a "homeland" (Lewin, 2005, p. 166). Similar arrangements are found among Bedouins groups of North Africa and Western Asia as well (Hughes, 2013). What distinguished the pastoral nomads living in periodic dwellings from those people living in episodic dwellings is that the former has a more homogenous culture and are structured in way that more resembles a political organisation, with an environmental impact that correlates with their increased dependence on agriculture rather than on the size and quantity of their livestock (Centers for Disease Control and Prevention and U.S. Department of Housing and Urban Development, 2006).

"Seasonal dwellings", on the other hand, are found in societies that are tribal in nature, i.e. seminomadic (Schoenauer, 2000). They are based on agricultural pursuits that are both pastoral and marginal. The latter, "marginal lands", refers to lands that have little or no agricultural or industrial value because whatever crops produced from this area would be worth less than any rent paid for access to that area (Peterson & Galbraith, 1932). Housing used by semi-nomads for multiple months or for a season can be considered "semi-sedentary" (Berry & Annis, 1974; Binford, 1990). Hence, the main difference between this type of dwelling and the aforementioned types is a more defined sense of property among the seasonal dwellers. However, the notion of property in this case is chiefly that of communal/shared property, rather than individual or personal property (Schoenauer, 2000). This type of dwelling is found in various environmental conditions. Examples include the hogans built by the Navajo people in North America (Jett & Spencer, 1981). Similar housing structures can be found among the Barabaig people in Tanzania and in Kenya and Masai people in Tanzania (Centers for Disease Control and Prevention and U.S. Department of Housing and Urban Development, 2006).

"Semi-permanent dwellings" is a type of housing used by sedentary folk societies or hoe peasants practicing subsistence agriculture by cultivating staple crops (Schoenauer, 2000). People living in these types of dwellings generally do so for different amounts of time, often several years, depending on the crop yields. They move on to more fertile lands once the extant land needs to lie fallow. Among those peoples in the Americas that used semi-permanent dwellings were the Mayans, who were known for their oval houses, and the Hopi, Zuni and Acoma Indians in the Southwestern United States, who were commonly associated with their pueblos (Hunter, 1986; Stewart, 1980).

"Permanent dwellings" signify a type of home used by sedentary agrarian societies. These are societies that are defined as "nations", containing political and social organisations, and have the means to possess surplus agricultural products (i.e. the ability to store and produce foods and crops for both sustenance and sales). The surplus of agricultural products enabled a different distribution of labour and freed up time and resources for other pursuits than sheer food production. Notwithstanding, that is not to say that was redundant, as agriculture still constituted the livelihood for a significant portion of the population. Examples of early sedentary agrarian dwellings are found in English cottages, for instance, the Suffolk, Cornwall and Kent cottages (Centers for Disease Control and Prevention and U.S. Department of Housing and Urban Development, 2006; Schoenauer, 2000).

The earliest evidence shows that urbanisation began in Mesopotamia circa 4000 BC (Savage, Warde, & Ward, 2003). Proto-cities (which lacked planning and centralised rule) have, of course, existed much earlier than that, such as the ancient urban settlement of Jericho (present-day Palestine) founded in circa 9,600 BC (Wiryomartono, 2020). Unlike "permanent dwellings", towns offered not only shelter and protection, but added an emphasis on providing comfort and an ease of living. The historical process that preceded urbanisation was relatively slow to initiate, but once started, it would accelerate rapidly. To put this process into context, a mere 3% of the world's population lived in urban settings with a population greater than 5,000 people during the 1800s, while in 1900, percentage increase was 13.6% compared to 1950, when it was 29.8% (Bhattarai & Conway, 2021; Kraas, 2008). By 1960, more than 30% of the earth's population lived in an urban setting, and by 1982, this figure had climbed to over 40% (World Bank, 2022). In 2007, half the earth's population had become urbanised, with 50.1% of all inhabitants being urban dwellers (Ritchie & Roser, 2018). According to the United Nations (2018), it is projected that 68% of the population will live in urbanised areas by the year 2050.

The Industrial Revolution served as one of the main drivers for urbanisation in the Western world, as this served to define the chief characteristics of what would later become towns and cities. To the point, the water from flowing rivers would provide the basic source of energy found during the early stages of the Industrial Revolution (Centers for Disease Control and Prevention and U.S. Department of Housing and Urban Development, 2006). Hence, towns and cities would crop up alongside the great waterways. Mills, for instance, are one of the most notable examples of an industry powered by water, however, water power varied with the seasons and it was not always available in addition to the fact that mills would always need to be physically located near a water source. Factory buildings were built of wood and stone, matching the house design and locations of the worker's dwellings. In this setting, workers were now able to live in close proximity to the place where they worked. However, this did not mean that people spent more time at home, since they would work long hours and earned little money while being cut off from their extended families, consolidating the prevalence of the nuclear family as an independent family unit (Browne, 2020; Knox, 2018). Moreover, the main source of power would, in time, change from water to coal (S. Morgan, 2008). This meant that steam, rather than water, became the main source of energy, and that brick and cast iron would become the main types of construction materials, which would, in turn, later evolve into steel (Centers for Disease Control and Prevention and U.S. Department of Housing and Urban Development, 2006; Mitchell, 2011).

People living in rural areas soon began migrating to the expanding cities in search for work. To exemplify, between 1861 and 1911, the population of England grew by 80% (Daunton, 1977). However, increasing populations in urbanised settings would also increase social problems. As mentioned, the workers during the Industrial Revolution would usually live close to their work. By the same token, these would be factories riddled with smoke and other pollutants. A slum began emerging. Moreover, there would be an overall lack of potable water and insufficient sewerage that would contribute adversely to the ensuing environmental, social and public health problems that would increase in parity with the ever-growing population. While the pre-urban housing and its sparse concentration of people would allow for people to physically remove themselves with ease from pollution, or at least dilute the existing pollution, the migration into an urban setting entailed that people were now locked in, living in close proximity to one another.

Understandably, this environment proved to be a cesspool for pandemics, and soon typhus, typhoid and cholera began spreading rampantly across the Western cities, resulting in high death tolls (Beggs-Humphreys, Gregor, & Humphreys, 1959). For instance, during the Industrial Revolution, children would have a probability of up to one in four of dying before their first birthday (Kosher, Ben-Arieh, & Hendelsman, 2016). As a result of these urban housing problems, social reformers such as Edwin Chadwick (1800–1890) began emerging. His famed 1843 report on the sanitary condition of workers in Great Britain sought many reforms, such as constructing ventilation and open spaces around the buildings (E. Chadwick, 1843). Beyond ventilation, his main contention was the need for better street cleaning, drainage, sewage and water supplies. Contemporaneously in Boston, Massachusetts, City Council member and bookseller Lemuel Shattuck released his "Report of the Sanitary Commission of Massachusetts" (Shattuck, Banks, & Abbott, 1850). The report made 50 recommendations, among which were suggestions on how to improve housing and buildings to protect school children.

This included installing ventilation and sanitising school buildings, while also focussing on town planning and managing overcrowded tenements and cellar dwellings.

In 1845, the City Inspector of New York, John H. Griscom released his report on the sanitary conditions of workers in New York (Griscom, 1845). Much like the aforementioned reformers, Griscom recommended housing reform and sanitation. Griscom is generally credited as being the first to use the phrase "how the other half lives" (Griscom, 1845, p. 5). This phrase has since been popularised in other urban studies and the living conditions of the destitute in slum areas, most notably by Danish-American social reformer Jacob Riis, whose work aimed to expose the slums of New York City to the upper and middle classes (Riis, 1890). One must also remember that the impoverished city dwellers during this time were not only subjected to the physical hardships of substandard housing, but in addition, they were often also victimised by scrupulous landlords and builders (Centers for Disease Control and Prevention and U.S. Department of Housing and Urban Development, 2006).

Nevertheless, since expanding throughout the world, cities are an integral part of the modern, advanced civilisation and in many ways considered to be the apex among human settlements (Sakyi, 2021). People remained in cities and the cities continued to expand. Homes began to develop technologically, and throughout the twentieth century, the use of appliances began to find their way into the average households. For the sake of convenience, many of these would eventually become automated. One example of which was the electric toaster. Prior to its first commercially successful introduction in 1909, toast was made by using a metal frame or a long-handled toasting-fork (Snodgrass, 2004; Thwaites, 2011). Others appliances would be electronically powered already from the get-go, such as the microwave oven (Datta & Rakesh, 2013). This was also how the "smart homes" would develop.

3 The Development of Smart Homes

What denotes "smart homes", in simple terms, is that they consist of a home automation system that monitors and/or control home appliances/attributes e.g. lighting, temperature, entertainment systems and (in some cases) security devices, such as access control and alarm systems etc. An integral aspect of a smart home is its connectivity with the Internet, or in other terms, Internet of Things (IoT) (Gitlin, 2021). The way a smart home works is typically by connecting controlled devices to a "gateway", which is a particular type of central hub. The mechanisms are controlled via an interface usually accessible from either more fixed constructs such as a wall-mounted terminal or a desktop computer, or from more mobile devices such as tablets or smart phones etc.

While largely popularised in the twenty-first century, the concept of first smart homes is not new. Much in the same way that Francis Bacon's aforementioned *New Atlantis* conceptualised techno-urban development in society, the smart home was envisioned in the literary world of science fiction long before it became reality. For instance, in *There Will Come Soft Rains*, mystery/sci-fi author Ray Bradbury (1920–2012) described, if not a "smart", then at least an "automated" home that is operational long after its human residents, the McClellan family, have perished following a nuclear bomb blast in a then-futuristic 1980s United States (Bradbury, 1950). In reality, however, smart homes are a reasonably new phenomenon. The first "smart" device devised for the home was *Electronic Computing Home Operator* (ECHO) IV, in 1966 (Cortesi, 2015; Tomkayo, 1994). ECHO IV was able to compute shopping lists, regulate temperatures in the home and turn appliances on and off. While technically the first smart device created, it was never commercially sold (Tomkayo, 1994). The first "smart" device for the home that actually reached the commercial market, albeit in a short-lived fashion, was the Honeywell H316 pedestal model, or more popularly, the "Honeywell Kitchen Computer" (S. Chadwick, 1985; J. A. Stein, 2011). The tagline used to market the computer was "If she can only cook as well as Honeywell can compute" (Misa, 2010, p. 172). However, as far as is known, no machine in this series was ever actually sold (Spicer, 2000; Watson, 2012). Released in 1969, it netted a cost of US$10,600, corresponding to roughly US$83,500, or ≈ €78,000, in 2022s monetary value (Alderman, 2007; US Inflation Calculator, 2022). The computer itself weighed over 45 kg (or more than 100 pounds) and was marketed as a device to help people store recipes (Archer, 2019; Heckman, 2008). Nevertheless, the designers would intend to add some additional uses, such as providing assistance with meal planning and balancing the household checkbook. It had a few inbuilt recipes and even had a built-in cutting board (Watson, 2012). In reality, however, the Honeywell Kitchen Computer would prove to be a far too convoluted machine to use for the average consumer among its intended target group. For instance, at the starting point, the user would need to undergo a two-week course (included in the price) just to learn how to use the interface, since it involved programming the device by using only toggle-switch input and binary-light output (Alderman, 2007).

While there were constant technological advancements in the ensuing years, smart homes as we know them, would not start to take shape until the early 2000s. This was enabled through the development of new and more cost-efficient, and user-friendly digital technology, as well as a more advanced Internet infrastructure. Smart homes would become a more affordable option, making it more viable for consumers than in the days of the Honeywell H316. It would not take long before various types of domestic technologies, and home networking devices began cropping up on the market (Hendricks, 2014).

The smart homes of today will tend to place a greater emphasis on upholding security than the daily household chores that earlier visions in popular culture would have predicted. Ensuring sustainability and providing a "greener" way of living is also a recurring trend among present-day smart homes, in order to make certain the household is not wasting energy unnecessarily (such as by turning off lights automatically in rooms that are empty) (Bibri, 2018).

Image 4.1 The Honeywell H316 "kitchen computer" from the late 1960s.
Source: sbfisher, Creative Commons.

One must also not neglect the economic impact and incentive brought forth in constructing smart homes and buildings. For instance, it is anticipated that the market for smart buildings will register a global compound annual growth rate (CAGR) at 12.6% throughout the period 2021–2027 (360 Research Report, 2021). Factors that are propelling the growth are increasing energy concerns and increased government initiatives on smart infrastructure projects.

The increase in "smart" homes and buildings indicate that there is a real demand for interactive spaces. Also, smart appliances, such as robot hoovers or smart dishwashers (with the ability to automatically select the correct programme based on the volume and items washed) may mean less time is spent on household chores. However, much work yet remains in order to ensure seamless automation in smart cities. A popular feature that is gaining more traction is developers adding local automation with the intent of designing the management of buildings easier, in addition to adding functionality for consumers and/or employees using the space. Consequently, there is much potential remaining for housing automation provided that city planners and administrators in charge of data infrastructures are able to harness the digital technology that is already in widespread use, while manoeuvring around bureaucratic red tape that impedes rapid development and deployment of "smart" infrastructure (Towers-Clark, 2019).

4 The Changing Nature of Housing

Contrary to other areas such as city infrastructure, traffic control, healthcare and communication networks etc., housing has rarely been made into a major talking point in the popular smart city discourse, and the discussion regarding "smart homes" and "smart cities" have largely been decoupled. However, the COVID-19 pandemic and ensuing lockdowns upended much of the conception of what a "home" actually is, with an increasing number of people having turned their home into a home office as well. This will need to put added requirements on the physical environment of the home and providing a safe and healthy environment, as the homes will under these circumstances not chiefly be frequented merely during the evenings and weekends, but for continuously extended periods of time. This means that there will need to be adequate amenities such as ventilation, heating, sound isolation etc. as well as sanitation of radon, nearby toxic waste, radioactivity, pollution etc. which is still a major problem for many houses across many cities in the world today (Azevedo, Silva, Lopes, Curado, & Lopes, 2020; Marzotto, Burnor, & Bonham, 2000; Theodore & Theodore, 2021).

On the technological side, the advent of 5G technology has also enabled greater bandwidth capabilities for cellular devices (Tuna & Cengiz, 2021). This, in turn, removes many of the technological barriers from working in other places than in the office. At the same time, it also enables the use of digital services that was not possible before due to technological restrictions.

As consumers have increased their usage of digital services following the COVID-19 pandemic, many new digital platforms have emerged for various services. This creates another problem because this means that the average denizen will need to use an application or a piece of software for each service they intend to use. In the future, there will be a need for a smarter and leaner solution. In this, the mobile network operators (MNO) will play a more significant part. However, this will necessitate collaboration between MNOs in order for a sustainable solution to be developed that can integrate the many different features needed in order to become relevant for multipurpose use (Wang, Nazi, Maurer, & Phadke, 2020). Enabling a user-friendly multipurpose platform that would provide easy access to digital services from the home, be they for work-related or private purposes, will become even more so pressing as future integrated circuit (IC) and wireless communications technologies enter the market (Rappaport, 2020). One example includes 6G, which is projected to be available on the market sometime between 2030 and 2035 and is expected to have the capacity to support virtual and augmented reality (VR/AR), as well as ubiquitous instant communications, and enhanced artificial intelligence (Dabadie, Vautier, & Bertin, 2022; Nayak & Patgiri, 2021). It is anticipated that Internet of skill (the process of technology where one can transfer knowledge, expertise and skills in real-time, without the restriction of physical boundaries) will become a greater part of the everyday household once 6G is introduced (S. Das, 2019; Dohler et al., 2017). 6G is believed to be able to deliver 100 gigabits per second to 1 terabit per second, while 7G, its proposed successor, which could make its foray on to the market around 2045, is believed to require about ten times as many antennas needed for 6G (Anwar, 2021; Saracco, 2019).

As the technological development towards Internet of skills is steadily ensuing, a greater number of technological impediments will be less of an issue. As the homes, and society at large, will be able to transmit massive quantities of data streams, there will be a need for a more holistic approach to the quality of life and what it means to build pandemic resilience through the means of technology. In other words, as opposed to focussing solely on connected infrastructure or how various forms of smart devices can interact with the city surroundings. A consequence of the pandemic is that it has created an awareness of the importance of the availability of affordable housing. According to the OECD (2021a), the COVID-19 pandemic renewed and accentuated concerns over persistent housing affordability and quality gaps among households, as many households found themselves without jobs and a steady income to pay for housing expenses. Moreover, problems with overcrowded housing also created an elevated sense of awareness in regard to sanitary conditions and the spread of viruses. As big cities have become increasingly more gentrified in recent decades, the issue of affordable housing has become a more salient talking point in the mainstream political debate, having been a lingering problem for many years (Lees, Slater, & Wyly, 2008; S. Stein, 2019).

According to the OECD, the recovery following the COVID-19 pandemic was stronger than originally expected (owing much to the support from governments and central banks), but markedly uneven in an international perspective across the economies, and particularly so in the "advanced economies" (OECD, 2021b). To this effect, an increasing number of cities are demonstrating a high discrepancy in median house prices and median wages (Roper, 2021). Hong Kong is the least affordable city in terms of housing, with median home prices outpacing median wages by over 20 times (Kwan, 2021). Among the most expensive cities across the world are Vancouver, Canada and Sydney and Melbourne, Australia (Ang, 2021; Roper, 2021). These cities demonstrate a housing price/median wage ratio discrepancy at around 10:1. Conversely, Los Angeles and San Francisco are the most expensive cities in the US, in spite of the latter's rents taking a plunge after the COVID-19 pandemic (Kwan, 2021; Paynter, 2020).

The acceleration of housing costs in some of the world's most attractive cities has led to a surge in small home and apartment purchases (Roper, 2021). Even though smaller flats in these cities are substantially pricier than housing in less dense global cities, smaller homes offer prospective residents a possibility to gain a foothold in a big, popular city at the cost of some living space. Nevertheless, this development has fuelled concerns of under-dimensioned types of housing arrangement often referred to as "micro-living", or more pejoratively, "coffin homes" (Harris & Nowicki, 2020). These types of homes, often found in cities with limited land areas such as Hong Kong, are notorious for being so small they basically offer no room whatsoever beyond a space to place one's mattress, or sometimes, if even a mattress takes up too much room, a thin linoleum sheet or a bamboo mat placed on top of wooden planks (Cheng, Mohamed, & Tang, 2015). Similar occurrences appear elsewhere as well. For instance, there is documentation of Londoners paying rent to live in walk-in freezers (Gentleman, 2012). On the other hand, small-area housing does offer an alternative for tenants who would otherwise be caught in a vicious rental cycle with dodgy sublease agreements and fickle landlords, or lessors, or even the sublessors. With the cost of rent skyrocketing even before the COVID-19 pandemic, many would argue that finding a sustainable solution to the housing problem is much overdue.

Housing insecurity has been a clear and present problem among low-income earners for a long time. For instance, as of 2019, more than 10 million households spent more than half their income on rent (Joint Center for Housing Studies of Harvard University, 2020). Following the COVID-19 pandemic, households in the US with an income lower than US$30,000 per annum began experiencing the highest rate of job loss and the slowest rate of recovery, with millions of families falling behind on their rent, which, in turn, led to the accumulation of debts they were not able to pay (Schuetz, 2021). A consequence of the pandemic was therefore for many low-income earners to double-up with their families or friends, thus living in crowded homes that increase the risk of spreading the pandemic further (Schuetz, 2021). This is in addition to other previously known health risks associated with crowded living, such as infectious disease and mental health problems

Image 4.2 A 63-year old man sitting in his "coffin home" in Hong Kong. The dwelling measures at 3x6 feet and is priced at HK$2,400 (US$310) a month. It houses the man's sleeping bag, a small colour television set and an electric fan, among other items.

Source: AP Photo/Kin Cheung.

(Memmott, Birdsall-Jones, & Greenop, 2012; Reynolds & Robinson, 2005; World Health Organization, 2018). Overcrowding also leads to the spread of diseases with epidemic potential such as acute respiratory infections, meningitis, typhus, cholera, scabies, tuberculosis etc. (Figueroa-Munoz & Ramon-Pardo, 2008; World Health Organization, 2021).

5 The Trouble with Overcrowding

The cities' infrastructure, capabilities and resources will vary immensely depending on the cities' ages and location etc. However, the growth rate of a city is indeed a key component. The manageable growth rate of a city is commonly held to be roughly 1% annually (World Population History, 2016). This figure denotes the level in which a city's infrastructure is able to keep up with a growing population and its demands. This includes essentials such as roads and public transit, sewage systems, water treatment facilities, healthcare facilities, education facilities and in particular, housing. These essentials need to be planned and built in proportion to the population increase. Should the city grow too fast, these essentials cannot keep up and this is particularly noticeable in a less economically viable country and/or city. Without the necessary essentials in place, the denizens are necessitated to create their own provisions with whatever means available, which, if unchecked, facilitates the formation of slums. Overcrowding also leads to underhousing, which leads to denizens finding unorthodox housing arrangements, such as either crowding together or taking up residency in places that are unintended, or unsuitable for housing. Moreover, studies have indicated that there is a causality between crowded households and poor educational attainment, which risks having long-term ramifications for many generations to come even once the pandemic is over (Goux & Maurin, 2005). What then constitutes an "overcrowded household"? According to Eurostat's (2021, para. 3) definition, a household is deemed overcrowded if there are fewer rooms than the total sum of:

- One room for the household
- One room per couple in the household
- One room for each single person aged 18 or more
- One room per pair of single people of the same gender between 12 and 17 years of age
- One room for each single person between 12 and 17 years of age and not included in the previous category
- One room per pair of children under 12 years of age.

Overcrowding is often connected to illegal housing (Ese & Ese, 2020; Gurran, Pill, & Maalsen, 2021). This is a commonly recurring problem in big, metropolitan cities such as New York etc. where the attractiveness is high but where the available liveable area and housing space are as limited as they are expensive. It is not uncommon for various types of basements to be (illegally) turned into flats, which offer lower-cost housing to tenants across the cities (Noveck, 2015). These flats often lack basic fire safety measures, like smoke detectors, sprinklers or an alternative exit (J. Morgan, 2007). Moreover, the tenants lack any and all forms of legal recourse in the event that a landlord would arbitrarily decide to evict them, or alternatively, if a government agency such as the Department of Buildings (or its city equivalent) was to decide to order the building vacated.

Needless to say, overcrowded housing is indeed real, and its consequences are severe, particularly so in times of pandemics where the spread of disease is rampant. The cities must provide affordable, quality and safe housing. While "affordable" is ultimately a matter of debate and largely a subjective opinion, there is likely no city that is internationally and indisputably considered to have succeeded in its ambition of providing fully affordable housing to all its residents. However, many cities have had greater aspirations of taking practical action in this direction. One notable example is Minneapolis, which in 2018 became the first major US city to promote affordable housing development and combat housing segregation by "upzoning" the entire city (please see Section "6. A Need for Policy Reform" in this chapter for a more in-depth discussion on what "zoning" entails) (Wegmann, 2020; Wheeler & Rosan, 2021). Previously, single-family residential zoning had limited housing supply and inflated the cost of homeownership. Additionally, these zoning requirements effectively served to bar many lower-income and minority families from moving into certain areas (Schwartz, 2021). In 2020, Portland, Oregon also passed a similar bill to the same effect, to eliminate single family-zoning (Dong, 2021; Schwartz, 2021). However, this practice has been challenged by other scholars, some of whom contend that aggressive zoning reforms and densification will not bring prices down in reality when considering opportunity costs etc. and that a better course of action would be to upzone the suburbs instead (Mallach, 2020; Schwartz, 2021; Tomalty & Mallach, 2015; Wheeler & Rosan, 2021).

Regardless, it is essential for cities to be not only effective but also preemptive in stymieing overcrowding, and proving affordable housing is indeed a key component in addressing the problem. The situations, of course, vary depending on country and city, but commonly recurring in most Western cities is that there is a lengthy, and often costly, bureaucratic process involved for landlords who wish to legalise conversions and basement apartments. In some cases, there is also property tax involved that increase considerably whenever buildings increase in size, such as from three units to four (Anas, 2003; Baird-Remba, 2015). These factors do little to incentivise landlords to seek legalisation.

What then can be done to remedy, or at least alleviate the problem? The first order of business is for the cities to acquire an accurate conception of which households are indeed overcrowded. To do this, cities must work across agencies in order to collect information from multiple sources. Specifically, this means there must be rules implemented that allows for the sharing of various dataset in order to compile and analyse essential data in order to actionable results to be achieved. This means there must be collaboration and data sharing across state, federal and/or third-party boundaries and that the cities must find ways to overcome legal and/or organisational resistance to information sharing. A concrete example to illustrate a problem in this regard is the fact that there are roughly 40 agencies operating in New York City that collect individual data for internal use exclusively (Weinberg, 2016). Localised data sharing on overcrowding makes any endeavour at information sharing extremely difficult at best and futile at worst and similar regulatory problems can be found in cities all over the world, with different cities in different countries tackling their own set of inert legal frameworks. This problem is often accentuated by the fact that different government agencies will often use different ontology of terms reflecting various individual operations, which cannot be easily transferred or tied together between different agencies. Ever so often, integrity is the cited reasons for not wanting to share information between agencies. Possible workaround solutions that the city could offer in this regard is to store a list of addresses rather than tenant names in order to determine the locations of potentially problematic buildings (Wallack, 2015).

Once the information has been compiled, it will be possible for cities to allocate funding in order to support initiatives aimed at reducing overcrowding. In this way, there are two primary ways in which data can be used. First, it can be used in a pre-emptive fashion, i.e. to prevent housing shortages. Second, it can be used to identify those overcrowded homes that are deemed to be most likely to be the most hazardous (Weinberg, 2016). In order to prevent overcrowding, data can be used to estimate the need for additional housing (Alamo & Uhler, 2015). As mentioned previously, Los Angeles is one of the most expensive cities in the US (and the world) as well as being exceptionally overcrowded (Alamo & Uhler, 2015; Menezes & Mihalik, 2021; Reyes & Menezes, 2014). However, the housing shortage is not a new phenomenon in California, as the problem has lingered since the 1970s (Alamo & Uhler, 2015; Smith, 2004). For this reason, the state of California has begun to review data in order to address the problem. More specifically, the authorities sought to develop a model that would compile information on house prices, education, incomes and the weather in order to determine likelihood or propensity of future demand (Alamo & Uhler, 2015; Weinberg, 2016). These factors were then to be juxtaposed and compared with housing supply estimates based on land area, topographical constraints and construction labour wages in order to estimate housing sufficiency and likelihood of overcrowding (Weinberg, 2016). Notwithstanding, the housing costs have remained steep with the median California home price at nearly US$700,000 in February 2021, roughly one year following the eruption of the pandemic (Greenblatt, 2022; Ohanian, 2021).

In the event that a particular area appears likely to become overcrowded, it would then be possible for the city officials to introduce programmes to take the pressure off housing. Examples of such programmes could involve relaxing development standards by, for instance, increasing the number of multi-family units for development, facilitation of single room occupancy through zoning code revisions, and expanding affordability by working with non-profits to assemble land and write down costs (Weinberg, 2016). By having access to shared and necessary data, the city authorities will stand a better chance at taking pre-emptive action and design housing policies to address problems of overcrowding before they even occur.

Notwithstanding, overcrowding is already an established fact in many cities and districts around the world (Ballantine, Roberts, & Korgen, 2020). In these cases, cities will need to utilise and harness available data in an effective manner, such as using predictive risk analytics to analyse what factors are facilitating the overcrowding. Processing available data can also assist building inspections to better pinpoint problematic buildings. By identifying the most endangered buildings, city officials can triage inspections and, in doing so, help conserve limited city resources and ensure that the regular practice of the fire services is followed (International Association of Fire Chiefs & National Fire Protection Association, 2020).

Keeping illegal conversions and various levels of distress under control is best accomplished by organising datasets so that priorities can be made beyond using mere traditional tracking and management tools (Newcombe, 2011; Weinberg, 2016). That is, cities will need to utilise datasets in new ways inasmuch as to not just gather historical data, but also data on matters concerning overcrowding. In this regard, traditional street surveys and thermal imaging have proven to be suboptimal in their aim. Instead, less traditional indicators have been providing more valuable insights. For instance, higher rates of "fly-tipping", or the illegal dumping of waste, can indicate overcrowding in a particular area, as can frequent calls to pest control teams (Barbosa & Peters, 1970; Blakemore, 2020; Vallero & Vallero, 2011).

In New York, a study looked at whether or not landlords paid taxes, if there were frequent noise violations, and complaints etc. in order to help identify probable candidates for various forms of building code violations (Flowers, 2013; Weinberg, 2016). For New York in particular, looking at and coordinating such datasets has proven to be highly effective. For instance, the authorities devised a model that was able to analyse incoming housing complaints received and flag those most likely to identify these highest risk properties, so they could be inspected within 48 hours (NYC Resources, 2011). Initially, of all the complaints received, approximately 8% (or 1,400 per year) accurately identified an illegal apartment where conditions were so detrimental that the city authorities would have to issue a "vacate order" (Copeland, 2015; Weinberg, 2016). However, by crosschecking and processing different datasets, the authorities were able to identify predictive indictors of the most dangerous buildings. The New York City officials were subsequently able to engineer a risk-prediction model that enables the city inspectors to identify over 70% of the worst buildings by targeting just 30% of them

(Scientist, 2013). This would suggest an improvement rate of approximately 233% (Copeland, 2015). Moreover, such a leap in productivity would lend support to the notion that devising risk models can help the city to pinpoint priority inspections and thereby saving the city much money and many resources in the process.

It is also important to note that there is a significant difference between *density* and *overcrowding*. The former refers to the number of people in the same place, whereas the latter refers to too many people in one and the same place. That is to say, it is possible to have a higher density of people in one area without it becoming overcrowded. Specifically, bad housing policies can lead to overcrowding in situations where there would not need to be any. For instance, in the US, only a mere 20% of all households are nuclear families. Likewise, single adults living alone make up about 28% of the US households, but more than 80% of the US houses and flats are built with two or more bedrooms. Ironically, the percentage of households featuring unrelated adults sharing a home corresponds to the same number as those living in nuclear families (Beyer, 2020). For this reason, it is not unusual for many singles to feel compelled to live together with people they do not know very well, if even at all, in homes originally designed for larger families. Also, by 2030, more than 20% of Americans will be of age 65 or older while only roughly 1% of the US housing is equipped to meet the needs of senior citizens (Herriges, 2019). This situation is by no means unique to the US, as many countries and cities around the world are wrestling with similar problems. Hence, a policy reform could help alleviate the situation regarding housing mismatches.

Another way of mitigating overcrowding and bringing housing costs down is to utilise the suburbs differently. A city's attractiveness, particularly amongst younger Millennials, who more often tend to blur the distinction between leisure and work hours, is largely determined by the accessibility and proximity of all the amenities they wish to use (i.e. home, work, shops etc.) (Buchnik & Frenkel, 2021; Öner, 2017; Vinodrai, 2018). Hence, an alternative to take pressure off the overcrowded big cities could be up "upzone" some of the suburbs, so that they also include the amenities requested and thus become more attractive for people to move into. It could also help reduce housing costs, as housing in the suburbs is invariably cheaper than it is in the most central parts of the big cities. A common counterargument against "upzoning" that it disrupts the suburban way of life (Harrigan & Von Hoffman, 2004). However, this is not necessarily the case, as some suburbs are far from the archetypical "sleepy small towns". Instead, there are some suburbs that are already growing, and promoting these as an alternative to moving into the city core could secure better control of the overcrowding problem. For instance, the city of Frisco, Texas serves as an affluent suburb to Dallas. Yet, it is one of the fastest-growing cities in the US, with a population soaring from 34,000 in 2000 to 164,000 in 2016 and was additionally named the "best place to live in America" by *Money magazine* in 2018 (Mishkin, 2018; Teaford, 2021). In 2019, Frisco planners approved a major makeover of the city's oldest and largest office development, which would add more than 2,000 residential units to the then more than 20-year-old office park, with additional options to construct taller buildings (roughly up to 122 metres, or 400 feet) in other areas of the city (Brown, 2019). Similarly, in suburban South Jordan, Utah, a large (4,126 acre/17 km^2) "new urbanist" development was set in place around 2019 that sought to mix different types of housing units in buildings that had similarly looking facades (Duke & Ewing, 2021; Furth, 2021). The intention was to create a walkable community that catered to a wider variety of budgets and walks of life (Furth, 2021).

Another way to expand the inhabitable areas of certain coastal cities is through the creation of man-made artificial islands (Dunn & Cureton, 2020). Historically, artificial islands have often served a role of various sea forts, such as the Napoleonic *Fort Boyard*, or *Maunsell Forts*, constructed during World War II (Kaufmann & Jurga, 1999; Lepage, 2010). However, in more recent years, artificial islands have been constructed across many cities in different parts of the world, often by means of land reclamation, with the intention of mitigating the overcrowding as well as enabling various large-scale commercial construction projects (Bolonkin, 2011). The *Burj Al Arab* hotel in Dubai is a notable example of a building constructed on an artificial island (Petti, 2008). A controversial aspect of constructing artificial islands is that they may damage reefs and disrupt marine life (D. Li, Tang, Hou, & Zhang, 2019).

Image 4.3 Coleman Boulevard, Frisco, Texas, USA.
Source: Michael Barera, 2019.

City-owned lots could also make more extended use of subterranean space. For instance, by constructing multistorey car parks underground, it is possible to free up available space above ground, possibly even building housing or other constructs on top. For instance, Nathan Phillips Square in Toronto, Canada, hosts one of the world's largest underground parking facilities at 2,400 car spaces (S. Taylor, 2021). Moving more of the city centre roads and railways underground could also be a way of freeing up more space for housing and other uses in some of the most congested and densely built parts of the city. This can also enable the construction of more trains and train tracks, which may have been restricted above ground, thereby improving traffic flow.

In terms of mitigating population density, on the other hand, one must look to a wider solution that often goes beyond the remit of what can be controlled or adjudicated on a city governance level. Save for severe measures, such as the "one-child policy" that was enforced in China during 1979–2015, or the "two-child policy" that replaced it (and has, at various points in time, been enforced by countries like Iran, Singapore and Vietnam), there are several other measures aimed at population planning (Abrahamian, 2018; Goodkind, 1995; Teng, 2007; Positive News, 2017). For instance, the emancipation/empowering of women is one such measure, since it is known that women with access to reproductive health services can more easily break the cycle of poverty (Bailey, Malkova, & Norling, 2014). Also women who work are more likely to use birth control (Tanfer & Horn, 1985). The United Nations Population Fund (UNFPA) (2021) is an example of an organisation that seeks to address both issues simultaneously by running microcredit projects to empower young women to advocate for reproductive health.

More generally, economic growth and education of women tend to have a stymieing effect to large families (Brander & Dowrick, 1994; Kim, 2016; H. Li & Zhang, 2007; Osili & Long, 2008). Relating particularly to the latter, yet another way to mitigate population density is through the promotion of family planning. Ensuring that the cities have adequate education for boys and girls regarding contraception goes a long way in keeping the population growth down. For instance, when Iran launched a national family planning programme in 1989, the fertility rate dropped from 4.7 births per woman in 1990 to 2.1 in 2019, and similarly, the birth rate in Rwanda dropped from 7.2 to 4.0 in the same time period (United Nations Department of Economic and Social Affairs – Population Division, 2020). Yet, another way of mitigating population growth is to make education about reproductive issues engaging and entertaining. For instance, the US-based entertainment organisation *Population Media Center* produces radio soap operas, which prominently feature culturally specific stories about women's rights and empowerment, reproductive issues and population stabilisation, is broadcast in more than 50 countries and reaches audiences of 500 million people (Barker & Jah, 2020). Another alternative, is for the government or city officials to appoint a senior government official responsible for addressing issues related to population stabilisation. This is a position championed by organisations such as the UK-based charity *Population Matters*. This organisation urges governments to promote "responsible parenthood", which entails that subsidies should be limited to the first two children unless the family is impoverished (Guillebaud, 2016; Martin, 2011).

6 A Need for Policy Reform

Zoning is the most common regulatory urban planning method used by local governments in developed countries and will undoubtedly continue to be essential to cities even in the future (Cheshire, Nathan, & Overman, 2014; Hirt, 2013; LeGates, 2005). Zoning is the reason why a home owner would not have, for instance, a steel factory as a next door neighbour. Essentially, it is what keeps a residential district residential, a commercial district commercial, an industrial district industrial and so on. Historically, zoning has served a means to preserve the safety and health of a city district. It also prevents the lowering of property value, such as having a residential area polluted by a nearby factory. Zoning laws can also regulate more specific construction details and standards, standards such as height, lot coverage, density and occupancy maximums, minimum setbacks (i.e. the minimum distance which a building must be set back from a certain place such as a street or road etc.), and minimum parking requirements (Elmendorf, 2007). In short, they serve as guidelines to guide urban growth and development (Hodge, Gordon, & Shaw, 2021). However, in many modern cities, many of the zoning codes are anachronistic, as are a lot of the dominant traditions in housing construction, which is detrimental not only to overcrowding, in general, but to limiting the spread of pandemics, in particular. While the status quo of housing does not necessarily mandate single-family homes explicitly, it does in many cases make it impossible to build anything else in a multitude of different locations (Herriges, 2019).

The problem of housing is also to a great extent reinforced by the fact that "missing middle housing" units are rarely included in the urban planning agenda nowadays, even though some small scale initiatives in bringing it back are abound (K. Parolek, 2015; Wegmann, 2020). This type of housing refers to a type of housing that was common in the US prior to World War II but is no longer, as housing construction would, in time, veer towards single-family with zoning. This made it difficult to build that type of housing with a walkable density between houses, hence it is referred to as "missing" (D. Parolek & Nelson, 2020; Wegmann, 2020). Alternatively, large, expensive apartment and condo complexes are built and these two options tend to form a housing dichotomy of this day and age, with few options for anything in-between. Essentially, missing middle housing constitutes a range of multi-family or clustered housing types, each of which are compatible in scale with single-family or transitional neighbourhoods. Missing middle housing is designed to meet the demand for walkable neighbourhoods, while at the same

Image 4.4 Illustration of the missing middle housing.
Source: Opticos Design.

time responding to increasing demographics, and in doing so, provide housing at different price ranges (D. Parolek & Nelson, 2020).

A 2014 report released by the American Association for Retired Persons (ARRP) showed that an increasing number of people want to "age in place", with a need for easy access to services and amenities available in walkable, urban, transit-oriented communities (Harrell, Lynott, Guzman, & Lampkin, 2014). By the same token, Millennials tend to drive less than earlier generations, and often seek out housing opportunities available in amenity-rich, walkable neighbourhoods with convenient access to public transportation (Shelton & Fulton, 2018; Sollohub, 2019). Still, cities and districts tend to maintain various zoning laws such as minimum parking requirement for different areas. This, in turn, drives up housing price while also hurting small businesses since they are forced to spend limited resources on conjuring up parking lot spaces (Marohn, 2018).

Still, many cities, particularly in developed countries, nowadays tend to focus on building pricier, higher-end housing. Apart from the previously mentioned zoning, there are a number of other reasons why this is happening (Herriges, 2018). First, new construction is expensive and in order to make it profitable for a developer to undertake the construction, it is likely that they will need to charge new/prospective tenants at a higher price range. For instance, as of 2015, the median price of constructing a single-family home was US$289,415, or US$103 per square foot, with an estimated annual increase of roughly 3.3% for labour, 4.5% for material costs, and 5% for subcontractor costs (Heidenry, 2021; H. Taylor, 2015).

Sometimes other types of well-meaning, but often unnecessary building code requirements assist in driving up the prices. For instance, some building codes may require fire sprinklers in residential buildings, but since the 2010s, the states of California, Maryland and Washington, DC mandates that sprinklers exist in any and all homes (National Fire Protection Association, 2021). The problem is that such requirements can add as much as six figures to the cost of a project (Marohn, 2017). At the same time, there has yet to be an epidemic of fire deaths in older buildings lacking state-of-the-art sprinkler systems. The total number of fire deaths in the US (residential and commercial) was 3,515 in 2019, corresponding to a death rate of 10.7 per million inhabitants (U.S. Fire Administration, 2021). While regrettable, this figure should be contrasted with the 36,096, or the 1.10 fatality rate per vehicle miles travelled (VMT), who fell victims to motor vehicle fatalities in the US in 2019 (National Center for Statistics and Analysis, 2020; Singichetti, Conklin, Hassmiller Lich, Sabounchi, & Naumann, 2021). Also, one in eight fires responded to by US fire departments are motorway vehicle fires (most commonly occurring in passenger vehicles and originating from the engine, running gear or wheel area), causing approximately 345 deaths per year (U.S. Fire Administration, 2018). Yet, the common drivers are generally not mandated to carry a fire extinguisher in their cars. A more salient point is that although it is easy to defend the sprinkler requirement in and of itself on safety grounds, its cost in the form of unbuilt housing that could have been built, makes it more difficult to justify given the housing shortage in different cities and areas. In this case, a more viable alternative in certain places could be to switch the sprinkler requirement to a requirement for smoke detector/fire alarm system requirement instead along with strategically places fire extinguishers, etc., which is considerably cheaper and is a less invasive procedure. In the future, it may be possible to utilise small, smart smoke detection systems able to detect smoke and combustible gas with great precision, such as the MQ-2 smoke sensor that also carries a 10–20% lower cost as opposed to traditional smoke detector systems (Yuen et al., 2018).

In other cases, construction costs may be propelled by other factors, such as whenever a city requires developers to use costly materials for use in the facades of multi-family structures in order to promulgate visual and architectural interest etc. (Herriges, 2019). Another hidden cost of development is found in the incessant time delays involved in local government review processes, in addition to potential multiple appeal processes. These delays, coupled with the ensuing uncertainties, impose additional costs for the developers, who may feel less inclined to undertake large, expensive projects if they know the project is bound to end up in a long and winding legal and/or bureaucratic process.

7 Conclusion

The aim of this chapter was to explore how smart homes can be improved in the future and how smart city housing can be ensured in the future while mitigating the problem of overcrowding and subsequently, the risk of further pandemic spread.

Action 1: Harmonise Access to Sharable Data among Governmental Agencies

There will be a need for authorities to collaborate more and share datasets across agencies and digital platforms. A step on the way to accomplishing this could be to harmonise, or at least make compatible, the databases and digital systems used between the different government agencies to enable the transference of data in a seamless manner as possible. In this way, the interests and needs of the city denizens could be better tended to while curbing the overcrowding and the risk of additional pandemic spread.

Action 2: Prepare Smart Homes for Future Technology

Cooperation will also be needed among the MNOs in developing a common digital platform to remove the unnecessary hassle of having to use different apps for different services around the house. While the market will often regulate developments in this domain on a supply/demand-basis, the implementation of new, advanced technology that requires new infrastructure to be built may often require various permits, and by extension, government involvement. Public funding may, in certain instances, also be used to help find the development of such infrastructure wherever and whenever necessary. Having the technological foundation in place is a prerequisite for many of the future smart houses that will need to be prepped and future-proofed for the impending 6G/7G-standards (and beyond) to the greatest extent possible. The future smart homes will likely revolutionise not only people's capabilities to work remotely but also the uses of digital technology in the home, in general.

Action 3: Address the Problem with Overcrowding

What can be done about the problem with overcrowding that afflicts so many modern cities today? At the end of the day, it is important to note that the city housing problem of today cannot merely be "built away" by just building more of the same. In fact, attempting to do so may actually have a boomerang effect. Should the city encourage more construction in high-density area, a possible consequence is that one inadvertently encourages speculation by land owners, who hope for windfall gains. Such speculation would, in turn, serve to drive up land prices, and thus work contrary to procuring affordable housing. Rather, the problem must be addressed at multiple angles and incorporate different actors.

Action 4: Modernise the Attitude Towards Housing Construction

To a large extent, city planners are still living by old traditions and building houses intended for residents that do not represent the majority of denizens. The current attitude does little to counteract the problem with overcrowding in the cities. City planners, therefore, need to reimagine housing construction and build more, and varied types of housing solutions. One example is, to reconsider building missing middle housing again.

Action 5: A Need to Ensure a Safe Home Environment Suitable for Extended Home Stay

To many people, their homes effectively turned into home offices during the pandemic. This also means that new homes will need to be reassessed, and certified if necessary, that they fulfil the criteria of a safe environment for extended home stays. In some cases, added amenities may be necessary, in particular regard to ventilation, heating, sound isolation, as well as sanitation of radon, nearby toxic waste, pollution etc.

Action 6: Take Better Advantage of the Opportunities in the Suburbs

Building affordable housing is difficult to achieve in the city core. However, many suburbs are already showing signs of expansion and offer great opportunities for additional and smarter expansion, such as providing opportunities for building more varied types of housing solutions.

Action 7: Do Not Neglect Enjoyable and Healthy Homes When Expanding the Suburbs.

The old adage of "one's home being one's castle" rings true in many ways. The pandemic illustrated the importance of having a home in which feels is secure, comfortable and creative, while staying healthy. Important to this effect is also the areas which immediately surrounds our homes, and the area in which we live. What will be a challenge in some cases is to expand the aforementioned suburbs while also ensuring an environment that provides access to green areas and spaces that are appreciated by the prospective denizens. Careful consideration and surveying of the lands will be needed prior to expansion in order to best determine whom one aspires to attract and what preconditions are there to provide a favourable environment that is appreciated by that prospective group.

Concluding Remarks

Ultimately, smart cities will need to work smarter, not harder. In order for a city to undergo substantial growth, the city officials will, in the future, need to carefully manage their housing stock without risking dangerous occupancy levels that threaten lives (Weinberg, 2016). Information sharing between government agencies should safeguard the well-being and sustainability of the residencies of the city but it must never be aimed at creating a society wherein "Big Brother" is omnipresent. While information sharing needs to be improved, there must therefore also be a system of checks and balances in place to ensure the purposes of sharing the data and when it may occur. The information sharing system should be feared by unscrupulous landlords, but never by the denizens at large. While the advancement of smart homes can offer many practical remedies and make life easier during, for instance, lockdowns, the main problem of housing today exists on a much profounder and far-reaching level. Specifically, much of the incumbent housing policy that exists in many cities today is outdated and needs to be revamped in order to better account for the contemporary society's needs. Overcrowding and clustering of large groups of people in the same vicinity is anathema for any attempts to keep the spread of pandemics within a city down, and therefore much focus must be directed towards ensuring that there is a sustainable solution to the overcrowding problem set in place.

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Part II

Facilities

5 Infrastructure and Travel

Travelling Safe in the Future

1 Introduction

An inseparable feature of any modern city is the existence of infrastructure and means of travel. This includes the existence of an adequate network of roads and public transport etc., in addition to public/governmental structures that help facilitate travel and it is in this way that infrastructure should be understood in the context of this chapter. Infrastructure may consist of either public or private physical structures, such as roads, railroads, other types of public transits, bridges, tunnels and several other public services including electrical grids, as well as telecommunications (including Internet connectivity and broadband access) that help facilitate the travel on any such structure.

Depending on the context, the term "infrastructure" carries several different meanings. In a strictly reductionist view, a city and its infrastructure is merely a collection of buildings and various facilities, such as parks, roads and utilities. Already today, many of these components are equipped with sensors to varying degrees and for various purposes (Towers-Clark, 2019). Networking these types of infrastructure into a digital system goes a long way towards establishing a smart city (Zantalis, Koulouras, Karabetsos, & Kandris, 2019). However, achieving full connectivity may prove problematic in certain places given various limitations such as restricted Internet access and dependency on cloud-based analytics services. The conventional infrastructure networks consist of main and major assets that are connected to pipes or feeders. Historically, the greater part of these assets do not communicate with one another and there is generally limited control utilities and few (if any) operational monitoring functionalities (Gürdür Broo et al., 2020; O'Reilly et al., 2001). For this purpose, a chief aim that a smart city seeks to accomplish in this domain is to establish digital infrastructure networks that can distribute a sufficient number of sensors to ensure that connectivity and control is established (O'Reilly et al., 2001).

Various new technological implementations are constantly being developed and fine-tuned. The development of 5G, edge computing (i.e. computing performed at or near the source of the data, bringing the cloud closer rather than relying on a cloud located at distant data centres) and technologies beyond,

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could increase the capacity immensely (Sapienza et al., 2016). Still, there are additional possibilities to be had when developing smart city infrastructure. For instance, smart grids could provide the cities with an energy production that is localised to a far greater extent. Moreover, hyper-localised forecasting would circumvent the issue of urban microclimates skewing forecast data (Duberry, 2019). This could, for instance, be achieved by connecting together temperature sensors that are already recording that data, and a similar solution could be achieved with security cameras in the event of a large-scale incident (Sterling, Brodowicz, & Anderson, 2018; Towers-Clark, 2019).

To the point, "smartness" is not merely a matter of replacing analogue technology with new, digital interfaces in various infrastructures, or streamlining city operations. Rather, it is a question of utilising smart technology and collecting data for the purpose of improving the decision-making ability and securing a better quality of life for the city's residents and enterprises (Braun, Fung, Iqbal, & Shah, 2018; Daniel, 2015). The aim of this chapter is to explore how infrastructure and travel within and between smart cities may be affected by pandemics such as COVID-19 and what can be done to improve travelling during pandemics in the future.

2 Infrastructure in the Era of Pandemics

Throughout the ages, epidemics, endemics, outbreaks and pandemics have had various effects on city infrastructure. For instance, the Plague of Athens is believed to have killed between 75,000 and 100,000 people, or roughly 25% of the population of Athens in ancient Greece in 430 BC (Littman, 2009). According to contemporary Byzantine scholar Procopius of Caesarea, the Justinianic Plague (AD 541–549) at its height reportedly killed approximately 10,000 people daily in Constantinople (Whately, 2021). Many cities in different parts of the world were recurrently affected by the plague, perhaps most famously so in the fourteenth century, where large parts of Western Europe were affected. Notably though, the plague mostly affected city dwellers and it is known that in the seventeenth century, death rates were generally much more extensive in urban areas as opposed to the countryside (Glaeser, 2011). While the plague as such would finally make its exit from the European scene in the early eighteenth century (although it would still linger in Asia), it was eventually replaced with other epidemics/pandemics such as yellow fever and cholera in the mid-1800s (Høiby, 2021; Tomori, 2004).

Protective measures towards early day epidemics, outbreaks and pandemics were generally restricted to quarantines, the concept having been developed in the fourteenth century to control the spread of the plague (LaBrunda & Amin, 2020). However, in the 1800s, new discoveries and innovations paved the way towards taking additional measures in combating the spread of epidemics and pandemics. In London, 1854, it was observed that a water pump located in the city was the root to much of the spread of cholera, since it appeared particularly prevalent among those who had drunk water from that pump (Caplan, Kennedy, & Neudecker, 2020). At the same time, people drinking alcoholic beverages in the vicinity appeared disproportionately unaffected by cholera. It turned out the alcohol would kill the waterborne bacteria, helping these people remain healthy (Aschengrau & Seage, 2020; Glaeser, 2011). The pump itself had become contaminated by a nearby cesspit that contained infected excrement that would, in turn, spread the disease (Glaeser, 2011). The lesson learned from this outbreak was the importance of the cities' ability to provide clean water to its denizens.

Another aspect that was brought to light was the effects of externalities. In simple terms, an externality is an impact brought by someone on to someone else who has not consented to being affected by the former actor's actions (Buchanan & Stubblebine, 2000). Specifically, this means, that in the case of the poisoned water, denizens could contract disease even if they picked a different water source located much further away. This was because many other denizens would still opt for the closer water well and in contracting the disease, they would pass it on to anyone who passed, including those who could walk the extra distance to avoid said water well (Glaeser, 2011; Spellman, 2021). In this way, externalities have always remained a huge factor in spreading diseases in cities.

Following the eruption of the COVID-19 pandemic, the pursuant lifestyles and active decisions made by individuals undoubtedly affected the way in which the pandemic was spread, and how people, knowingly or unknowingly, allowed it to affect others by their attitudes and individual life choices. For instance, in a 2020 interview, British musician Noel Gallagher discussed his attitude towards not wearing a face mask, arguing that it was a violation of his liberty, adding: "I choose not to wear one. If I get the virus it's on me, it's not on anyone else" (Beaumont-Thomas, 2020, para. 2). The lesson here is that even if a majority of a society's members will do all that they possibly can do in order to mitigate the risks of spreading sickness and contagion, and even if these people were to fully comply with any and all of the authorities' stipulated mandates; disease will always continue to spread as long as there is the occasional anomaly that will not adhere to the majority's efforts to contain the spread. This has remained a truism throughout the centuries and will indubitably continue to be so. This can be due to personal attitudes (as in the case of Noel Gallagher) or out of necessity (such as the case of the ailing and impoverished nineteenth century denizens who were unable to make the trip to cleaner water wells). Whichever the reason, it is necessary to account for the fact that not every denizen will follow the various rules and recommendations set by the governing authorities to mitigate the spread of pandemics. For this reason, it is more important than ever to consider the infrastructure we build in our cities and how we travel, and to construct our cities in a way that makes it easier to stem the tide of pandemics. With the development of smart cities, new possibilities have been made available and it will require a multifocal approach to how we plan the city's infrastructure and our future modes of transportation.

3 Smart Transport

3.1 Streets and Roads

One area of infrastructure that has seen radical change due to the development of smart cities is the city streets and urban roads. Over the past century, roads have been designed to keep traffic moving. However, their designs have historically been disinterested in sustaining life alongside it. That is to say, that in many cases, city street design offers meagre alternatives for denizens to manoeuvre around since they discourage walking and stifle vibrancy. In fact, inefficiently designed streets are estimated to account for chronic congestion and approximately 1.24 million traffic-related deaths each year along roughly 35.5 million km of road worldwide (Sadik-Khan & Solomonow, 2016). Besides traffic accidents, other traffic problems include traffic jams, pollution, fuel cost, fuel scarcity, high insurance premium costs, and so forth. The population boom and influx of people into our modern cities have led to a drastic increase of cars, bicycles, motorbikes and other types of road users adding to the aforementioned traffic problems (Toh, Sanguesa, Cano, & Martinez, 2020).

In many cities, the street infrastructure is in many ways obsolete, as they were originally built to serve denizens of a different era with different needs and in different quantitates than of today. Car-based urban areas have been largely unable to keep up with the population boom of the twentieth century, with the only adjustments mainly consisting of the addition of more obsolete infrastructure (Buhaug & Urdal, 2013; Linn, 2019). Many seemingly logical measures at alleviating traffic congestion, such as widening city streets or even constructing new motorways, have often had a contrary effect as these measures are short-term at best and ultimately only serve to cause further harm to the city's core, such as by stifling the liveable areas or lowering the city's practical and aesthetic value and thereby also its attractiveness. The "problem" with city streets is that they are ultimately perceived as a means for moving vehicles rather than a place for people to enjoy, which means that the more roads are built, the less room is left over to build other infrastructure that the denizens can appreciate better (Sadik-Khan & Solomonow, 2016).

Still, roads are essential for transportation, which forms the arteries for mobility and the economy alike. The transportation of goods and people enables business to operate and helps cities flourish. For long, transportation has been viewed as a typical civil and structural engineering problem. Along with the growth of smart cities, however, this has, in many respects, changed as the issue of roads is now increasingly becoming coupled with the emerging digital technologies (Toh et al., 2020; Zantalis et al., 2019).

Traditionally, the transportation infrastructure has entailed large amounts of revenue to the cities in the form of various sources such as taxes, tolls and roadside parking etc. (Shoup, 2005). While the national government will often own infrastructure such as the motorways and interstates, the cities will often control the local roadside, passthrough streets, certain tolling infrastructure and revenue accrued through parking solutions. Generally, these sources of revenue are collected in collaboration with various service providers. What was seen during the COVID-19 pandemic was that many of these resources diminished due to people staying in their homes, observing social distancing, using less public transit and working remotely (De Vos, 2020; Hörcher, Singh, & Graham, 2022; Schiener & Yarger, 2020).

3.2 Managing the Traffic Flow

A pandemic such as COVID-19 illustrates the need of understanding traffic flows and the need of having a more fluid traffic condition. To this effect, the concept of "smart transport" has materialised. Smart transport essentially entails the ability for various traffic systems to integrate different data sets from across static, real-time and dynamic data sources with the use of sensors, meters and software (Alizadeh, 2021). This may include smart roads, smart street lights, smart cars and smart traffic signs (Galanis, Anagnostopoulos, Gurunathan, & Burkard, 2019; Toh et al., 2020; Umamaheswari, 2021). Since the mid-1990s, transportation-related technologies have evolved considerably.

In a society that promulgates smart transport, it follows that there are "intelligent" (i.e. digitalised) signs and roads as well (Kim & Khan, 2018; Toh et al., 2020). In this society, roads will no longer be perceived as merely a physical construct, but rather as "empowered" infrastructure with smart communications to all its users and sensing capabilities that are only made possible through the use of digital technology. To this end, one can expect an expanded use of intelligent transportation systems (ITS) in the future. In simple terms, ITS is an advanced application that seeks to ensure the supply of services pertaining to different modes of transport and traffic management so that it allows travellers to be better informed and make safer and more coordinated use of transport networks (Alam, Ferreira, & Fonseca, 2016; Heise, 2016). As such, the main benefit of ITS is that it increases the capacity of heavily trafficked and/or congested roads while reducing the time needed to travel. Moreover, many of the ITS systems that have been in development since the outset of the twenty-first century have emphasised surveillance of the roadways (Monahan, 2007). While this may originally have been devised with issues concerning homeland security in mind, it also allows for other possibilities as well. For instance, ITS would enable the possibility to call for emergency services whenever an accident occurs, employing cameras to enforce traffic laws or changeable speed limits signs (or otherwise) in areas with dynamic settings and flexible conditions (Iqbal, Khan, Abbas, Hasan, & Fatima, 2018). More importantly, ITS can play a decisive role in the speedy mass evacuation of denizens from cities or urban centres following large-scale critical events, such as natural disasters, terrorist attacks or even pandemic eruptions (Sharifi & Khavarian-Garmsir, 2020).

To this end, it is predicted that the global growth in the ITS market will register a compound annual growth rate (CAGR) of 7.0% from 2021 to 2028 (Grand View Research, 2021). A practical application of an advanced ITS system can be seen in Singapore, with its over 160 km network of expressways and road tunnels. Singapore has one of the most refined ITS systems in the world, with hundreds of devices, sensors and cameras spread across the island to gather data on traffic flow, travelling times and road demand (Carter & Rushton, 2020; Government of Singapore, 2022c). This enables travellers to obtain the necessary information to help plan their trips ahead of time. Singapore also hosts a number of specialised ITS solutions. One of these is the "Green Link Determining (GLIDE)" system, implemented in 1988, which controls all traffic signals in Singapore by adjusting the time of the "green light" on the traffic light as the traffic flow changes (Chin, 1998). Moreover, GLIDE links adjacent traffic signals to allow vehicles to travel from one junction to another with minimal stops. GLIDE is designed to use loop detectors to detect the presence of vehicular and pedestrian traffic and makes traffic signal adjustments to occurrences such as parking guidance systems (PGS), and expressway monitoring systems, which allows for a better traffic awareness and traffic flow (Chin, 1998; Government of Singapore, 2022b).

Other systems include the "Expressway Monitoring Advisory System" (EMAS), which is an intelligent incident management tool designed to manage traffic along the expressways by detecting accidents and incidents swiftly so that normal traffic flow can be restored as quickly as possible (Ho & Chin, 2016). EMAS also provides travel time information on signboards to motorists before they enter the expressways (Government of Singapore, 2022a; Ho & Chin, 2016).

Another feature is the PGS, which was launched in 2008 (Elm & Carvalho, 2020). It provides detailed information across 29 roadside electronic information panels so that motorists are able to see which parking spots are available even while driving. As the information is provided in real-time, it greatly reduces the time needed to circulate across the streets in pursuit of a free parking spot within the central business areas and major shopping districts. It also helps motorists avoid the worst crowded areas as well (Elm & Carvalho, 2020; Government of Singapore, 2022d). It is on this note prudent to mention that owning a car in Singapore is exceedingly expensive, much due to the city introducing several programmes, such as taxes on car ownership, set in place to actively discourage consumers from buying cars (Duarte & Firmino, 2018). In this way, there are already financial incentives in place to regulate much of the Singaporean traffic congestion in addition to technical solutions.

Regardless, incentivising traffic guidance, while bringing stability to local small and medium businesses throughout cities, may be done in many different ways. This may include using a digital PGS, which could enable local businesses to offer discounts for nearby parking. An open transportation grid that would gather data points for streamlining and managing could help create a smoother traffic pattern across cities with smaller road grids. In such a system, transportation centres could interact with different delivery services, calculating their routes and arranging for parking reservations (Liu, Yan, Wang, Yang, & Wu, 2017; Yellajosyula, 2020). In this way, the stream of traffic could be managed so that delivery services would be able to make their drop-off without risking causing back-ups on narrow, busy roads (Liu et al., 2017; Schiener & Yarger, 2020).

To this end, some cities already now employ "congestion charges" (Kristoffersson, Engelson, & Börjesson, 2017). This entails a system in which the city surcharges motorists entering and/or exiting a city, with the price usually being higher during peak hours. Proponents argue that the intent is to mitigate unnecessary traffic to and from the city, thereby reducing congestion and emission, while at the same time procuring an additional source of income for the city (Small & Gómez-Ibáñez, 1998; Small & Verhoef, 2007). Critics, however, will argue that congestion charges are mostly about political subterfuge from local and regional politicians and that its main purpose is not to mitigate city traffic, but to find alternate means of securing revenue to fund new transport infrastructure instead of raising taxes and thereby risking the ire of the voters during the next election (Hysing & Isaksson, 2015). It should, in this context, be stressed that congestion charges are distinct from toll roads. It is in the case of the latter that the primary intent is to secure revenue generation for issues such as repaying road investments, or financing capacity expansion, operations and maintenance of roads, or as a means of generating general tax funds (Deakin, 1989; Federal Highway Administration, 2019). Major cities that have employed congestion charges include London, UK; Stockholm and Gothenburg, Sweden; Milan, Italy and Singapore (Lehe & Devunuri, 2021). Some smaller towns and cities also utilise congestion charges, such as Durham, England; Znojmo, Czech Republic; and Valletta, Malta (Eliasson, 2014; May, Koh, Blackledge, & Fioretto, 2010). Riga, Latvia previously had congestion charges, but ended the initiative in 2008 (Cooke, 2018). As mentioned, congestion charges are designed to charge extra during peak hours. However, traffic varies not only on an hourly basis, but also on a daily basis, and is contingent also on other factors, such as holiday seasons, roadwork, operational public transit, etc. Thus, in the future, digital technology would be able to survey and provide a better estimate of the actual level of congestion and a more efficient and flexible system could be employed.

"Smart roads" carry promises of many other features as well. For instance, there have been emerging initiatives to develop technology with the ability to harvest energy from the roads. To this effect, there are many different ways in which this may be accomplished. Some include harvesting energy from sunlight (popularly known as "solar roads") while other methods involve mechanical vibrations produced by vehicles as they transverse the road, thereby generating electrical energy (Williams, 2018; Zou et al., 2019). Thus, solar energy harvested from the roads can be used to power street lights, signage

Image 5.1 Smart road system in Gotland, Sweden.
Source: Smartroad Gotland.

and traffic signals (Toh et al., 2020). Naturally, the accrued energy may also be stored or distributed to the electric power grid. This technology has the potential of changing the future of energy production. On these roads, photovoltaic modules could be placed directly on top of road surfaces in order to capture sunlight. The energy generated could also be used to illuminate street dividers during the dark hours and for melting ice and snow during the cold seasons. One example is the "Smartroad Gotland" project located on the Swedish island of Gotland. Smartroad Gotland is a 1.6 km long wireless electric road charging system that is able to charge electric cars while driving (Hájnik, Harantová, & Kalašová, 2021).

The other type of aforementioned "smart road" is what is commonly referred to as a "piezoelectric road". These are special types of roads, as they generate electricity whenever a vehicle passes over it. This happens due to what is known as a *piezoelectric effect*. This, in simple terms, refers to the ability of certain materials to generate electric charges in response to applied mechanical stress (Poplavko, 2019). Simpler yet, these types of materials produce electricity whenever any kind of mechanical stress/force is applied. The energy is generated through piezoelectric devices that are buried approximately five centimetres below the upper surface of the roads (Khalili, Biten, Vishwakarma, Ahmed, & Papagiannakis, 2019; Moure et al., 2016). Whenever a vehicle travels across the road and drives over one of these devices, the wheels exert force into the piezoelectric device, causing a "deformation" in the material. This "deformation" absorbs the force, initiating the process of power generation. If placed along a one-kilometre stretch, these piezoelectric devices could provide an average of 400 kilowatts (kW) of power per day, which in itself would be enough to run eight electric cars (Kumar, 2013). Since traffic flow rates, i.e. number of vehicles per hour passing the road, affects power density, piezoelectric technology is best suited in areas with high traffic flow rates. As of today, piezoelectric devices have been deployed by the East Japan Railway Company (under subway station gates at Yaesu North

Gate, Tokyo Station) and by Innowattech Ltd. in Haifa, Israel (under roads) (Laskar, 2017; Toh et al., 2020). Yet, another early day type of "smart road" energy harvesting is through the use of dynamic speed bumps in order to convert kinetic energy to electric energy from passing vehicles. This model was proposed as part of EU FP7 POWERAMP project, which sought to bring about energy harvesting speed bumps that capture energy from vehicles that pass over the ramps (European Commission, 2010; Toh et al., 2020).

The aforementioned energy harvesting methods are but a few that are currently in development. The harvesting of energy in this way will become particularly beneficial in times of a pandemic eruption, where energy sources will become scarcer the longer a pandemic and the ensuing lockdowns progress. Testament of this was seen during the COVID-19 pandemic in particular, where the implementation of various public health measures had considerable global ramification on the energy systems, most chiefly caused by the acute staffing shortage. For example, in the US, almost 600,000 workers in the clean energy industries were made redundant in March and April 2020, with little over one-sixth of these being added back in June 2020 (Mulvaney, Busby, & Bazilian, 2020). Regardless, the effects of such measures across such vast segments of the economy are bound to have longstanding ripple effects across the energy industries for years to come.

3.3 Stemming the Spread of Virus in Traffic

There are, of course, many other valuable "smart" transportation technologies to be used. In particular, hygiene and temperature control has become a salient issue following the COVID-19 pandemic. Apprehension about being infected by other passengers sharing a public transport ride, or using the ride after someone who has been potentially infected has used it, will be a lingering concern that will become essential to address (Tirachini & Cats, 2020; Yellajosyula, 2020). In remedying this condition, it is conceivable that there will be more extensive use of thermal and optical sensors along with various hygiene control procedures such as humidity scans, regular UV disinfecting, and hand sanitation monitoring (Afzal et al., 2020; Bradley, 2020). These steps would also need to be automated to the greatest extent possible in order to ensure that the necessary health and safety standards in the vehicles, waiting areas, terminals and stations are upheld.

Already now, an increasing number of electric vehicles (EVs) are being put into traffic. The main selling point for EVs has typically been that of environmental and economic purposes, as to reduce emissions and overcoming the escalating costs of petrol. However, with additional pushes from large companies such as Google and Uber, self-driving autonomous vehicles (AVs) are currently being designed, created and tested (Bodhani, 2012; Toh et al., 2020). According to the standards developing organisation, SAE International (2021), there are six levels of driving automation, ranging from no driving automation (Level 0) to full driving automation (Level 5). Level 0 entails no automation whatsoever, whereas in Levels 1 and 2, it is more a question of "support systems" such as steering and/or brake assistance, adaptive cruise control and so forth. Automation of vehicles in the "autonomous" sense begins at Level 3, as it is at this point the automated system begins to monitor the environment rather than having the human driver do so (Peng, 2021). At Level 3, the vehicle performs most driving tasks but requires prompting/initiation by a human driver, who may also cancel the automated driving sequence at any time. At Level 4, pedals/steering wheels may not be available, but control may be assumed by a human driver. At Level 5, the vehicle is fully automated without any attention or interaction required from a human operator. At present, Level 5 vehicles are not yet available to the general public, with 2030 as the anticipated roll-out date (Ahangar, Ahmed, Khan, & Hafeez, 2021). However, some experimental projects have been tested in various cities. For instance, between November 2017 and October 2018, the City of Las Vegas deployed a free-service automated shuttle bus within the Fremont Entertainment District of downtown Las Vegas in order to allow the public to experience the autonomous driving technology first-hand (Dennis, Paz, & Yigitcanlar, 2021). Studies have shown that human drivers, in general have only needed to take control of the vehicle for a small portion (5%) of the entire journey (Darapureddy, Kurni, & Saritha, 2021). In theory, one of the advantages with automated vehicles is that they may lead to few traffic accidents and fewer insurance claims, with some predictions that traffic accidents could drop by 80% by 2040 (Ullrich, Butz, & Diefenbach, 2021). However, one of the most potent risks of automated vehicles (particularly, of those which retain elements of human control) is that the driver risks developing an overtrust in the system and thereby fails to react in time when needed in order to avoid an accident (Payre, Cestac, & Delhomme, 2015; Ullrich et al., 2021).

Although the concept of AVs remains a contentious issue, the COVID-19 pandemic highlighted the potential role that AVs could play in securing speedier responses during emergencies, while also helping to prevent the spread of diseases and keeping the risk of infection down (Kapser, Abdelrahman, & Bernecker, 2021; Yellajosyula, 2020). Another concept introduced alongside AVs is the concept of "platooning", or "flocking". In simple terms, this is a method for driving a group of vehicles together as a means of increasing the road capacity via an automated highway system (Noruzoliaee, Zou, & Zhou, 2021). Platooning serves to decrease the distance between vehicles using electronic coupling, which allows for multiple vehicles to accelerate or brake at the same time. Platooning also allows for a closer headway between vehicles since there is no need for a reaction distance, which is otherwise needed whenever there is a human reaction involved. While the debate concerning platooning has gained additional traction in the wake of AVs, it is not an entirely new concept, as it has been recurrent in the scientific debate for decades (Swaroop & Hedrick, 1999).

The idea of platooning and AVs are that each vehicle would then be able to automatically join and leave platoons. The main arguments favouring the implementation of a platooning system for AVs is that it offers greater fuel economy due to reduced air resistance, while also reducing the risk of traffic collisions as well as reducing congestion and thereby substantially shortening commutes during peak periods. This in turn, also takes some pressure of public transit by train as the roads will be able to offer a much faster way to travel (and thereby making bus travel a more attractive option). The disadvantage with platooning, is the obvious risk of system failure, much like with anything that is digital. In this case, this also includes the possibility of hacking from a remote computer, which could create extremely hazardous situations (Greenberg, 2016; Menn, 2015). Nevertheless, much work remains to be done in order to fully roll out AVs. For starters, much effort would need to be put in on order to build public trust and confidence in such artificial intelligence technologies and to ensure that the technology is reliable enough to ensure the physical safety of the general public. However, it is important to bear in mind that AVs do not by necessity entail that they will always drive in a platooning fashion, and thus it is important to not confuse the concepts.

Notwithstanding, platooning has in later years found an additional purpose also among automated lorry transports (Janssen, Zwijnenberg, Blankers, & de Kruijff, 2015). The main advantages are that there is significant reduction of drag (or "air resistance") for all trailing lorries as well as a strong flow-vehicle interaction between the leading and the trailing lorries, meaning that the fuel may be used more efficiently (Deraro, Nallamothu, Nallamothu, Nallamothu, & Zewudie, 2021; He et al., 2019). However, a platoon lorry is more vulnerable to lateral instability than an isolated one, meaning that, in theory, there is a greater risk of the lorry tipping sideways (Dukkipati, 2000; He et al., 2019). Also, as electrification becomes more widespread, the advantage of platooning as a means of conserving fuel will diminish. In fact, research indicates that while lorry platooning would reduce petroleum consumption by no more that 4% in 2060, electrification would reduce the consumption 13-fold relative to platooning (Bridgelall, Patterson, & Tolliver, 2020).

3.4 The Future of Travel

With the promises brought on by 5G-technology, Internet of Things (IoT) devices and sensors would be able to keep decision latency to a minimum in order to facilitate immediate incident response (X. Li, Zhou, Angela Zhang, Jiao, & Li, 2020). The aim would be for roadside accidents to be eliminated or at the very least greatly reduced, even in the most densely populated city areas. Moreover, "anomaly detection", which is essentially complex event streaming joined with data management capabilities, could also prove instrumental to verify the urgency of events in real-time while facilitating predictive interventions (Santhosh, Dogra, & Roy, 2020; Yellajosyula, 2020).

Cars and roads will, in one form or another, remain an integral part of the city's skyline for the foreseeable future. They help facilitate traffic within a city and they also help facilitate traffic between cities. However, transportation between cities and within cities will take on different forms in the future, and also the way in which we travel. We can, in this context, make a distinction between *intra-city* travel (within the same city) and *inter-city* travel (between cities). The lattermost should not be confused with "interCity" (non-hyphened with an uppercase "C"), which is a classification applied to certain long-distance passenger train services in Europe (Garmendia, Ribalaygua, & Ureña, 2012; Grimaldi, Augustin, & Beria, 2017). It is distinguished from other types of train services such as regional, local or commuter trains inasmuch that they will generally stop only at major stations.

As roadable vehicles become increasingly more electrified, a more pressing concern is the matter of securing an adequate supply of power. For example, research by Transport for London (TfL) calculated that Britain would need to secure enough energy corresponding to 20 additional nuclear power stations, should the electric car completely replace the petrol engine for all cars in the country (Paton, 2017). Some have suggested that the construction of small modular reactors (SMR)[1] could help sustain the future transition to vaster number of EVs (Porter, 2017).

4 Intra-city Travel

4.1 Roadable Aircrafts

Already now, there are early day initiatives for roadable aircrafts (or "flying cars") pursued by companies such as AeroMobil and Terrafugia, or personal air vehicles (PAVs), which is an emerging type of aircraft proposed to provide on-demand aviation services such as the proposed NASA Puffin, or the Boeing Passenger Air Vehicle (Polaczyk, Trombino, Wei, & Mitici, 2019). Some have been trailblazing the preparations for the roadable aircrafts, such as New Hampshire, which on July 28, 2020, became the first state in the US to create a legal framework for registering, inspecting, and plating roadable aircrafts by signing the "New Hampshire House Bill 1517" (Dodds, Chopitea, & Ruffins, 2022). The legislation has more popularly been nicknamed the "Jetson Bill" after the 1960s, animated sci-fi/comedy-themed series "The Jetsons" in which one of the lead characters, George Jetson, was frequently seen transporting himself and his family in a "flying car" (Dodds et al., 2022; Tegler, 2020). Under this law, owners would pay a US$2,000 municipal permit fee, while the craft itself would adhere to road rules whenever driving on the streets (Dyer, 2020). Landing on public roadways would be prohibited (save for cases of emergencies), as is crossing over into another state.

Indubitably, the very notion of a "flying car" has caught the allure of many, and the concept has been visually depicted for many years in popular culture in everything from old sketches to Hollywood films such as *Chitty Chitty Bang Bang* (Hughes, 1968) and *Blade Runner* (Scott, 1982). While roadable aircrafts would allow for people to travel without risk of viral exposure from other travellers in cases of pandemics, it is unlikely that roadable aircrafts will become a widespread phenomenon across the globe in the foreseeable future.

Beyond the technical aspects, there are still many impediments remaining. First, the technology still has limitations and there is no market ready for mass-production yet, meaning that the few early versions on the market will most likely only cater to those of extremely affluent means (Financial Times, 2017). Second, in regard to electric versions of roadable aircrafts, batteries currently lack the energy density to adequately power vertical take-off and allow for merely more than a few minutes of flight. The difference between regular cars is that weight blunts their efficiency, whereas for aircrafts, weight kills their efficiency. Third, there are immediate safety concerns when moving urban transport from two to three dimensions. Similarly to the aforementioned AVs, automated evasion systems are still not flawless (Financial Times, 2017). Adding to this is a, for good reason, far stricter certification process for components used in aircrafts than in automobiles. Fourth, there is currently no air traffic control system in place that allows for more than limited use of drones (Financial Times, 2017). Fifth, there are additional concerns regarding the certification process of the drivers/pilots, the support systems as well as of the vehicle itself (Ahmed et al., 2020).

Although it will likely be a while before roadable aircrafts become a commonplace possession in the average household, roadable aircrafts as taxi services carry greater potential for a sooner roll-out. Among the world's first roadable aircraft, taxis were announced on the Consumer Electronics Show (CES) in Las Vegas, Nevada in January 2020 by Hyundai and Uber, with projections of rolling out services to other cities as well such as Dallas, Los Angeles and Melbourne (Ansari et al., 2021;Su-Ro, Young-Jin, & Seung-Mok, 2022). The Hyundai Uber taxi is capable of flying at speeds up to 290 km/h (or roughly 156.6 knots) (Henama, 2021; Hyundai, 2020).

Image 5.2 Flying car concept art by Hyundai and Uber.
Source: Hyundai.

A similar Japanese equivalent manufactured by the aircraft manufacturing company SkyDrive, is called "SD-03" and is set to launch its taxi services in 2025 after having first been showcased at CES in January 2022 (Stonor, 2022). Also, a related technology that may show some potential in the future if developed further, is the "personal electric aerial vehicle" such as the Swedish designed "Jetson ONE", launched in 2022, at a cost of roughly US$92,000 (Cansdell, 2022; Nevans, 2021). Essentially, it works as a single user vertical take-off and landing (VTOL) aircraft that can hover, take off and land vertically without relying on a runway, but with a considerably smaller frame, lighter weight (approximately 86kg) and Tesla batteries granting the user about 20 minutes in the air (Cansdell, 2022).

4.2 Public Transit

Public transit is a quintessential feature to the millions of people around the world, who rely on it daily. Overcrowded public transport systems such as buses and trains have been a scourge for practically any city that has them, and in many ways, this is a problem that has been left unaddressed by city governance for too long. Some have argued that COVID-19 did, in fact, not break the public transit, but rather highlighted what was indeed broken (Snyder, 2021; Tirachini & Cats, 2020). It also led to people across cities feeling less inclined to use various modes of public transport. For instance, in Thessaloniki, Greece's second largest city with more than 1 million inhabitants in its metropolitan area, 34.3% of the surveyed population in 2020 claimed to no longer be using public transport due to the COVID-19 pandemic with another 45% purporting that they had reduced their use of public transport (Moovit, 2020; OECD, 2020b). In other places, authorities undertook action to prevent infected travellers from boarding different modes of public transport. One example was Seoul, South Korea, which implemented at least ten bus shelters with ultraviolet lamps to kill viruses and cool the air, in addition to being equipped with thermal-imaging cameras to scan the travellers' temperatures and only permitting them on the bus if they registered below 37.5°C/99.5°F (Loke & Rakotonirainy, 2021). In spite of this, crowding in public transports remained a risk factor since the overall drop of ridership does not necessarily mean that there are fewer passengers on specific routes. This was the case in Toronto, Canada, in which the public transit commission saw an initial ridership drop of 80% during the early stages of the pandemic, but soon realised that there were a few routes (particularly those bound towards the industrial worksites) with high numbers of commuters, resulting in crowded services (Neis, Butler, Shan, & Lippel, 2022). Of course, this was not circumscribed to merely Toronto, as similar trends were observed globally (Cho & Park, 2021; Tubis, 2022).

To this end, the overcrowded public transportation has gone from being an inconvenience to becoming a potentially lethal hazard. This has accentuated the need to improve the quality and means of safe transportation. Digital technology that addresses road congestion has more effect on cities where driving is prevalent or where buses serve as the primary mode of public transport. One way of reducing congestion is to ensure that there is a steadier traffic flow (Barton & Tsourou, 2000). To illustrate, it is estimated that by the year 2025, smart cities deploying smart-mobility applications could potentially reduce the average commuting times by 15–20% (Woetzel et al., 2018). Naturally, the level of benefit is largely dependent on factors such as the existing transit infrastructure, commuting patterns and, of course, the city's density. To this end, it is incumbent on the city planners to identify the worst "bottlenecks" and either expand the traffic on these routes, or ensure that alternate modes of transportations are made available there during times of pandemics, such as combining bus and train transit, or deploying direct shuttle buses between the two or three destinations that carry the greatest number of passengers etc.

To many people, the idea of a "15-Minute City" would be utopic, with its promises of increasing city resilience by keeping all important tasks in close proximity, and further reducing the need of environmentally unfriendly transport (Moreno, Allam, Chabaud, Gall, & Pratlong, 2021; Whittle, 2021). Some argue that the 15-Minute City has the potential of reducing the pandemic spread by effectively eliminating the need of public transportation and crowding (OECD, 2021; Veeroja & Foliente, 2021). Essentially, the 15-Minute City refers to a residential urban concept in which most daily necessities may be accomplished by no more than 15 minutes of travel from a resident's home, ideally by either walking or cycling (Moreno et al., 2021).

Of course, variants consisting of 20- or 30-Minute Cities also exist, but the key concept remains the same (Capasso Da Silva, King, & Lemar, 2020; Levinson, 2019). Prior research indicates that approximately 20 minutes is the maximum length of time that people are willing to walk in order to complete a daily task of chore before opting to use some alternate means of transportation; a concept also known as the "pedestrian shed" (Jacobsen, 2020; Whittle, 2021). Certain cities have championed this idea more than others. A notable example is Paris, France, which in 2020, proposed a concept known as "*ville du quart d'heure*" [Eng: "the quarter-hour city"] (Parkinson, 2020, p. 74). The reform would, to a large extent, entail that many main roads through Paris would become inaccessible to motor vehicles, and so-called children streets would be set up next to schools during term time among other changes (Willsher, 2020). Other examples of cities that have championed the 15- or 20-minute concept, or "hyper proximity", are Melbourne, Australia; Copenhagen, Denmark and Utrecht, the Netherlands (Whittle, 2021; Willsher, 2020). Houston, Texas adopted a similar "complete streets" concept in 2013 to reinforce the image of having a "walkable city" (Whittle, 2021).

The drawback with the 15-Minute City, from a pandemic resilience perspective, is that, it places great emphasis on the built environment. While, as previously mentioned, it will reduce the dependency of public transport on a day-to-day basis for most city dwellers, it will lead to more compact buildings and, most likely, more high-rise buildings, which, in turn, means that a greater number of people will have to share amenities such as lifts and public spaces (Veeroja & Foliente, 2021). Hence, a risk is that one would merely move the crowding issue from the public transport to places closer to home. Also, some critics hold that the 15-Minute City initiatives as seen in Europe, would translate poorly into a North American setting, where people are more dependent on cars given the vast geographic spread between home, work and various necessities, and that efforts to bring all of these things within a 15-minute radius would be seen by many residents as a means of attempting to force gentrification on the areas, and in the long run, forcing the current denizens to eventually move out (O'Sullivan, 2021).

Contrasting the 15-Minute City is "Marchetti's constant", named after Italian physicist Cesare Marchetti (1994), although it is conceptually believed to have been originated by British philosopher Bertrand Russell (1872–1970) (Mumford, 1934). The "Marchetti's constant" stipulates that the average tolerable time spent by a person commuting each day, is approximately one hour (Marchetti, 1994). However, some interpretations have limited this timeframe to half an hour (Whittle, 2021). As a theory, Marchetti's constant posits that although the modes of urban planning and transport may change over time, and in spite of the fact that some people live in rural areas while others live in urban areas, people will eventually adjust their lives to their living conditions, which includes the location of their homes relative to their workplace, so that the average travel time stays approximately constant, hence "Marchetti's *constant*" (Ausubel & Marchetti, 2001; Ausubel, Marchetti, & Meyer, 1998). That is to say, that people would spend the same amount of time travelling on a day-to-day basis travelling in, for instance, ancient Greece as they would, in this day and age, with the only distinction being the vaster distance covered in that time due to more advanced modes of transport (Gately, 2014). Unlike the "15-Minute City", the idea behind Marchetti's constant does not seek to achieve hyper-proximity where everything essential is reachable on foot. Rather, it seeks to expand the distance in which one may travel in as short as time as possible, and under 30–60 minutes (Whittle, 2021). Still, there are physical limitations to Marchetti's constant as well.

Marchetti (1987) himself envisioned that humans one day in the future could travel distances at Mach 8. While modes of transportation have undoubtedly become more advanced, the human body can only withstand approximately 5 g of g-force before rendering unconscious, meaning that, barring the inconvenience of always strapping on a g-suit beforehand, any future vehicle able to travel at that speed would need to accelerate and decelerate at slower speeds (Gately, 2014). Also, some research suggest that time sensitivity is a greater factor for intermediate distances and less so for distances that are notably short or exceedingly long (Johansson, Klaesson, & Olsson, 2003). From a strictly economic perspective, one may contend that any travel that can be pushed significantly so that it falls under the Marchetti's constant can, in turn, be considered to be part of the same city region (Johansson, Klaesson, & Olsson, 2002). The implication is that there would be a greater economic significance if one were to reduce the travel time from 50 minutes to 30 minutes between two cities, than if one were to reduce it from three hours to two hours.

Nevertheless, an important point raised by Marchetti's constant is the aspiration of creating a public transit system that is as efficient as possible and that will keep transit times down to a bare minimum, and thereby limiting one's time in risky environments. In a city with a high population density and an extensive public transport infrastructure, smart technologies could save the average commuter approximately 15 minutes of travel time each day. In contrast, one can in a developing city, with underdeveloped means of communing, expect an improvement of approximately 20–30 minutes per day (Woetzel et al., 2018). One concrete example of a city taking such measures is Peking (Beijing), China, which has introduced an online booking platform that gives travellers fast-lane access to trains. The expectation, for the system, is to reduce ticket waiting times by up to 80% and shorten standard queues by 40% (World Economic Forum, 2021).

Of course, there are physical measures one may undertake to reduce travel time, such as the construction of tunnels, bypasses, underpasses, overbridges etc. to ensure a traffic flow that is as straight as possible and reduces additional traffic disruption from surrounding areas as much as possible. However, digital technology also has the potential to streamline traffic flow for cities that utilises advanced public transport infrastructure. In using digital technology to deliver real-time information about potential transit delays, it is possible for travellers to adapt their routes and mobility patterns "on the fly". By installing IoT sensors on existing physical infrastructure, public transit staff can help address problems proactively before they cause breakdowns and possible delays. One may also take on a multimodal approach, such as in Berlin, Germany, where a series of actions were implemented in order to reduce the travel times, such as the 2018 "Berlin Mobility Act" that seeks to expand various forms of mobility such as bicycles, car sharing etc. (Stark, Schuppan, Kehlbacher, Jarass, & Gebhardt, 2021). Other measures include the "Berlin Pass", which is set to provide lower or even free fares for denizens of lesser means to ride the public transport in order to increase demand and intracity travel, as well as introducing ten-minute schedules for public transit (World Economic Forum, 2021). There is also the "Berlin Mobility Assistance Service" that aims to provide free personal support (save for the cost of a valid ticket for public transportation) for the elderly and people with disabilities to use public transit for visiting the doctor or for shopping trips etc. (Pflegestützpunkte Berlin, 2021; World Economic Forum, 2021).

In the future, public transit will need to place a heavier emphasis on social distancing and personal hygiene. As user-needs are individual and will fluctuate greatly, there will be a need for operations to be able to match the individual need in a dynamic fashion. This means that there will be a need to adjust vehicle dispatches on various routes, along with the possibility of suspending services on other routes according to government directives. It also means adhering to various load/capacity restrictions, and so forth (Yellajosyula, 2020). Naturally, all of these measures would need to be balanced with managing resource allocation, including fuel consumption, along with other primary operational attributes. With the ability to combine different data streams from different sources, including internal as well as third-party data sources (e.g. weather, passenger information, traffic) along with (anonymised) historical travel and passenger information, it is possible to assist the operators in leveraging prescriptive analytics in order to make real-time service adjustments as to provide for optimal operational efficiency. Moreover, this data can also be used to convey real-time updates to travellers across multiple channels (such as mobile apps, live displays at the stations etc.) for improved communication, transparency and safety (Yellajosyula, 2020).

An automatic train operation (ATO) can best be described as an operational safety enhancement device used to assist in automating the operation of trains (Yin et al., 2017). The issue of ATOs has for long been a contentious issue. On the one hand, it is seen as a step towards having machines replacing more human labour in addition towards fanning people's safety concerns in having automated systems ensuring the safe travels of all passengers. On the other hand, there is the argument that ATO will increase the efficiency of operations while also keeping train staff safer in times of pandemics as it removes one additional point of human contact, if human drivers are not needed on board the trains.

The degree of automation is indicated by the "grades of automation (GoA)" (Sarkar & Jain, 2018). As stipulated by the International Association of Public Transport (UITP) (2018), there are five GoA of trains, ranging from GoA level 0 to GoA level 4. As outlined in Table 5.1, the following levels Trestour and De-Reuck (2015, p. 7) define the different levels as follows:

- GoA 0 is a train driver on-sight operation, similar to a tram system running in street traffic, reliant entirely on train driver to manage the system safety.
- GoA 1 is a train operation where a train driver controls starting and stopping, operation of doors and handling of emergencies or sudden diversions, but with an automatic train protection (speed and signal past at danger protection control).
- GoA 2 is semi-automatic train operation (STO) where stopping is automated but a driver in the cab starts the train, operates the doors, drives the train if needed and handles emergencies. Many ATO systems are GoA 2.
- GoA 3 is driverless train operation (DTO) where starting and stopping are automated, but a train attendant operates the doors and drives the train in case of emergencies.
- GoA 4 is unattended train operation (UTO) where starting and stopping, operation of doors and handling of emergencies are fully automated without any on-train staff.

Table 5.1 The five grades of automation (GoA) of trains, according to the International Association of Public Transport (UITP) (International Association of Public Transport, 2018).

Grade of automation (GoA)	*Mode of train operation*	*Description*
GoA 0	On-sight	No automation.
GoA 1	Manual	A train driver controls starting and stopping, operation of doors and handling of emergencies or sudden diversions.
GoA 2	Semi-automatic (STO)	Starting and stopping are automated, but a driver operates the doors, drives the train if needed and handles emergencies. Many ATO systems are GoA 2.
GoA 3	Driverless (DTO)	Starting and stopping are automated, but a train attendant operates the doors and drives the train in case of emergencies.
GoA 4	Unattended (UTO)	Starting and stopping, operation of doors and handling of emergencies are all fully automated without any on-train staff. All stations must have platform screen doors.

Already now, GoA 2 is implemented in several countries across many urban passenger railways, such as many parts of the London Underground, and the Washington Metro. It is currently in development in many other places as well. The Ontario Line is proposed have a GoA 4 driverless system and is slated for introduction in 2030 (Metrolinx, 2019; Spurr, 2020).

GoA 3 and GoA 4 would, in times of pandemics, likely be the safer option for train staff, but nevertheless, a full transit to employing a fully automated system at all times, even in times when there is no pandemic, means the public would need to place their complete trust in such operations. Thus, this is likely to be a more delicate political discussion, albeit one that is already carried out in many different places.

Similarly, the development towards autonomous buses has also made much progress. For instance, Stockholm, Sweden launched a small scale project with automated buses on a trial basis in a few suburbs already in 2018 (Ainsalu et al., 2018; Oldbury & Isaksson, 2021). Nevertheless, some studies have had reservations against the prospects of fully automating all buses since they are not able to provide the same care and attentiveness towards certain vulnerable members of the population (e.g. elderly and disabled) in the same way that a human driver can (Epting, 2021; Stjernborg, 2019). This is because all cities are unique and some city designs may provide obstacles to these passengers in ways that an automated system following a set of heuristics cannot account for adequately enough (Epting, 2021).

Another issue that we can expect to see more of in the future is the wider implementation of contactless fare payment (Brakewood, Ziedan, Hendricks, Barbeau, & Joslin, 2020). While this already exists for public transport in many cities around the world, the aspiration would be to altogether remove passenger interaction with any physical payment terminals or kiosks that require the use of cash, along with anything that requires contact with publically used surfaces such as PIN Pads and touch screens etc. (Yellajosyula, 2020). To this extent, mobile ticketing along with the use of digital wallets would allow passengers to make transactions in a secure and hygienic manner through their smart devices e.g. smart phones or any other type of "wearables". Another advantage with this is that mobile ticketing reduces friction points and improves the overall passenger experience by eliminating various waiting time at ticketing counters, while still being able to adhere to the social distancing norms. In addition, mobile ticketing would also keep staffing costs down while speeding up lead times and scheduling (Yellajosyula, 2020). The flipside with mobile payment, is that it still requires the customer's trust in the mobile payment adoption, something that varies greatly across the globe and is an overall issue that still needs much work (Madden, Banerjee, Rappoport, & Suenaga, 2017; Xin, Techatassanasoontorn, & Tan, 2015).

Another issue is that the "cashless society" may discriminate against people who do not possess the technological means or skills. Another argument is that removal of currency, in its physical form from society, creates a shift in the balance of power from the individual to global, private actors (Eriksson & Sandhill, 2020). However, the most disconcerting problem in removing cash is the utter dependency on the digital payment systems being fully operational. We know, for a fact, that this is not always the case, and during a pandemic there is an elevated risk of various outages. The risks of abandoning the cash-based infrastructure was manifested during the spring/summer of 2021, when large parts of the Western world were struck at various occasions by the private ransomware-as-a-service (RaaS) operation "REvil" (Szücs, Arányi, & Dávid, 2021). One attack, in particular, was orchestrated by infecting hundreds of managed service providers through the desktop management software by the Florida-based software company Kaseya Limited. REvil locked and encrypted the data held on these systems and demanded a US$70 million ransom to restore the encrypted data (Reeder & Hall, 2021). This attack affected between 800 and 1,500 businesses around the world, many of whom were forced to completely close down their shops for lack of not being able to accept cash in lieu of cashless payments (Brown, 2021; Parson & Killian, 2021). Sweden was one of the countries particularly affected with hundreds of grocery shops being forced to shut down for several days, among other businesses (Brown, 2021).

Sweden is often cited as one of the most "cashless" countries in the world (Wood & Morris, 2020). Nevertheless, a 2021 study by the Swedish Civil

Contingencies Agency concluded that disruptions in cashless payments could have severe consequences and recommended citizens to keep some cash at home as a precaution (Van Laere et al., 2021). While this recommendation is prudent in the event of cyber-attacks such as REvil's, it also presupposes that there is a functioning infrastructure to handle cash payment. Thus, the Swedish example should serve as a cautionary tale of what perils to expect should one allow an unmitigated and unchecked digital transformation to exclusively cashless systems and/or infrastructure to continue.

4.3 Micromobility

The term "micromobility" refers to a range of small, lightweight vehicles typically operating at speeds below 25 km/h (OECD, 2020a). These vehicles are manoeuvred by users personally and includes modes of transportations such as bicycles, electric bicycles (e-bikes), electric kick scooters (e-scooters), scooters (e.g. Vespa), electric skateboards, Segways, public bike share (PBS) schemes, and electric pedal assisted (pedelec) bicycles (a type of low-powered e-bike) etc. (Frosio, 2020; Yang et al., 2020).

Although popularised in the twenty-first century, various forms of micromobility, such as bicycles and scooters, have been around since at least 1817, and would continue to be used fairly regularly by people up till around 1908, when cars made their foray into big cities such as New York City etc. (Sovacool, 2009). After this period, bicycles would continue to be used for recreation and/or sports, but would be used drastically less as a utilitarian urban transport mode for many countries and cities across the world (albeit with a few notable exceptions, such as some cities in China, Denmark and the Netherlands etc.). Nevertheless, in many major cities, there exists a bike-sharing system, which entails a system in which bicycles are made available for shared use to individuals on a short-term basis for a price, or in some cases even for free (usually due to ad-sponsoring or marketing promotions etc.) (DeMaio, 2009; Vogel, 2016). Interestingly, the bike-sharing system has proven to be more resilient to pandemics than public transit in the sense that there was a lesser drop percentagewise (71% vs. 90%) in the number of ridership during the COVID-19 pandemic than there were for travellers using public transit (Teixeira & Lopes, 2020).

In recent decades, however, micromobility has, in some measure come to, if not replace, but at least to supplement, public transit. This particularly applies to short distance bus rides, but it has also had an impact on some people's walking habits, leading to reduced physical activity (Moreau et al., 2020). However, as a solution to the "last-mile problem" (i.e. transporting passengers to the oftentimes most resource draining final leg of their destination), the supportive role of e-scooters would appear to be more limited. Studies have shown that the arguments of e-scooters drastically reducing the use of public transport have likely been overstated, although shared e-scooters are more likely to substitute public transport trips than would regular bicycles (though this difference appears to gradually diminish the shorter the trip is) (Nawaro, 2021). Additional concerns have been raised regarding the life-cycle emissions of various types of electric micromobility modes, most notably the e-scooters (Moreau et al., 2020). There is also some potential in replacing car trips as well. According to a study by Gebhardt et al. (2021), roughly 10–15% of all the surveyed motorised individual transport (including cars, lorries, motorbikes etc.) could be substituted by e-scooters. However, another study by Sanders et al. (2020) indicates that e-scooters also disproportionately replaces walking and bicycling for all trip types, which may have some negative public health implications in the future when people become more sedentary and less physically mobile.

E-scooters are powered by an electric motor and hold a maximum speed of 25 km/h and an average speed of 6–10 km/h in pedestrian areas (Gössling, 2020). It is estimated that there were 20 million e-scooter users in Europe alone in 2020 and the adoption rate of e-scooter sharing is four times faster than that of bike sharing (Latinopoulos, Patrier, & Sivakumar, 2021). On the other hand, shared e-scooters have had one of the most rapid adoption rates in transport, accounting for 3.6% in one year. This can be juxtaposed against the bike-sharing, which took eight years to reach a 13% adoption rate, and the carsharing, which took an entire 18 years before it reached 16% adoption rate in major US cities (Clewlow, 2016; Populus, 2018). Commonly, micromobility vehicles and bicycles across many parts of the world share existing bicycle infrastructure, e.g. protected bicycle lanes, cycle tracks, cycle highways and off-street trails (Oeschger, Carroll, & Caulfield, 2020). It has thus been possible to use micromobility vehicles without further investment to the infrastructure. Similarly to owning a bicycle, owners have not needed to register micromobility vehicles used for personal use, nor has one needed to pay any form of vehicle registration fees, or maintain a liability insurance (unless such an insurance is procured on a voluntary basis) (Elliott & Metz, 2020; Reid, 2019; Sokolowski, 2020).

However, micromobility has given rise to some additional concern. The primary case against some micromobility vehicles, and most particularly e-scooters, has been their physical interference and their "invasive" role for the built environment. This is the main reason for why some cities, such as Paris, France, at least temporarily outlawed e-scooters for a month in 2019 (Rachmanto, 2021). The secondary case against e-scooters has entailed the numerous accidents involving the vehicles across multiple cities, which has sparked fiery debates on their role in city traffic (Kleinertz et al., 2021; Latinopoulos et al., 2021). It is not uncommon for the injuries to constitute high-energy trauma that primarily affects head and upper extremity with one study indicating that as many as 17.7% of victims sustained major head injuries (Moftakhar et al., 2021). The tertiary case against micromobility is that there is a growing concern as to how micromobility infringes on personal integrity. With smart technology, companies behind micromobility vehicles are able to track and survey users. There are also growing concerns regarding the legality of some of the apps these devices use. Many micromobility companies will employ a standard for exchanging data between mobility operators and cities or other regulators. Essentially, this is a system that consists of several APIs to allow agencies to analyse/interpret data from mobility operators in a standardised format in addition to implementing regulation digitally (Monahan, 2020). One example of such is "Mobility Data Specification (MDS)", which was developed by the Los Angeles Department of Transportation (LADOT) in 2018 (Los Angeles Department of Transportation, 2018; Zipper, 2019). While MDS is (thus far) focussed on dockless scooters, bikeshare and carshare; it has the potential to expand to additional transportation modes and services (Roukouni & Homem de Almeida Correia, 2020; Y. Xu et al., 2022; Zakhem & Smith-Colin, 2021).

4.4 Autonomous Passenger Ferries

Many ideas have been presented as a means of reducing city traffic off the streets (Zhang, Qi, Yan, Tang, & Wang, 2017). One such suggestion has been to move more traffic out to the waters in maritime cities, where such possibilities exist. Investments in water transit infrastructure would thus be an inexpensive and less disruptive way of relieving congestion in transport networks since the waters would not require any roads to be built. Also, ferries have been seen as a viable way of keeping long-term emissions down (Reddy et al., 2019; Zhang et al., 2017). However, ferries are generally costly to operate due to the level of manual labour required. To this end, autonomous ferries could present a viable option for maritime city travel. A few cities such as Trondheim, Norway and Turku, Finland have already launched prototypes of autonomous passenger ferries (Reddy et al., 2019; Wright, 2020). Also in Amsterdam, the Netherlands, there is an autonomous passenger ferry project called "Roboat" (Duarte, Johnsen, & Ratti, 2020). During its initial stages, the autonomous passenger ferries, such as the one operating in Trondheim canal were only able to serve a smaller number of passengers, roughly up to 12 passengers (Guo, Haugen, & Utne, 2021). This means that autonomous passenger ferries are not contenders to replace traditional ferry services in major cities for the foreseeable future, or at least not until there are more effective means of supplying the ferries with electricity beyond the already existing fuel/battery cells. Also, in order to make autonomous passenger ferries safe for use during times of pandemics, one would need to ensure that there are proper sanitation possibilities on board the small vessels. There would also need to be adequate isolation capabilities to mitigate the risk of viral transference between passengers not belonging to the same company. Nevertheless, autonomous passenger ferries are still largely a work in progress, although one can no doubt expect to see more of this development in the future.

Image 5.3 Autonomous passenger ferries as envisioned for future operations.
Source: Zeabuz/Stoppeffekt.

5 Inter-city Travel

5.1 Train vs. Aircrafts

Naturally, in a smart city, there needs to be an infrastructure in place for inter-city (or even long-distance) travelling as well beyond "smart roads" for vehicles. A salient topic that has been discussed much in recent years is, whether trains or planes are the superior option for domestic long-distance travel (Glusac, 2019; Román, Espino, & Martín, 2010). For long-distance, international travel, aircraft will undoubtedly be the uncontended superior option for most people for the foreseeable future in regard to convenience, price and speed. However, it is commonly held that the spread of a pandemic is merely a plane ride away (Elbe, 2010). In this regard, technology could assist in reducing spread.

In February 2021, the Danish government announced it would introduce "digital coronavirus passports" amidst the COVID-19 pandemic. The "passport" was in essence some documentation made available at the Danish digital health portal, sundhed.dk confirming that the person travelling had been vaccinated against COVID-19 (Mageit, 2021). The rest of the EU soon followed suit and the concept developed into the "EU Digital COVID Certificate (EUDCC)" – previously known as the "Digital Green Certificate", and was launched in July 2021 to help Europeans travel easily between the member states as well as to some non-EU countries as well (Goldner Lang, 2021; Gstrein, 2021). The EUDCC was designed to be presented as a *Quick Response*, or QR-code that the traveller could carry either as a digital or a paper certificate, containing information about his/her vaccination status, test results or recovery status from COVID-19 (Goldner Lang, 2021; Steiner & Veel, 2021). Naturally, some other countries would develop their own iterations of the "COVID-19 passport", but the principle would notwithstanding remain the same (Goldner Lang, 2021).

In the future, there will most certainly be an even more advanced, universal and flexible system that can account for a greater variety of situations that can be applied and restricted to areas wherever there is an ensuing pandemic brewing, or an existing epidemic/outbreak that may resurface from time to time, such as Ebola etc. For instance, an internationally recognised database where passengers wishing to travel could submit verified test results shortly ahead of flights could be introduced and activated at airports whenever and wherever necessary. However, for domestic, or shorter-distance international travel, the situation is different, as there are more viable options to choose between. For commercial travel, this choice is often between trains or planes.

Historically, one of the chief selling points for the plane has been the shorter travelling times, whereas proponents for the train, especially so in recent years, will often cite environmental metrics (Glusac, 2019; United States Department of Transportation, 2019). Specifically, it was in 2021 estimated that the US inter-city rail services carried 57.15 passenger miles per gasoline gallon equivalent (GGE) as opposed to the airline's 51.40 passenger miles per GGE (U.S. Department of Energy, 2021). Conversely, the main argument against train travel is that it is comparatively slower in speed, whereas for airplanes, there are recurring environmental concerns. However, two major technological advancements have sought to address each of these concerns, namely the high-speed rails (HSR) and the electric aircraft.

5.2 High-Speed Rails

In later years, HSR has been presented by some politicians as a viable, and environmentally friendly, alternative to the airplanes. HSRs have been particularly popular in China, which has built 29,000 km of HSR as of December 2018, accounting for two-thirds of the world's total HSR network (Tang, 2018). Proponents of HSRs will also argue that it is many times the less pricey alternative for individuals and that while HSRs are slower in and of themselves than aircrafts, they proffer faster transportation times than aircraft on account that they typically take passages straight to the city centre while airports that are, with very few exceptions, located several kilometres outside of the city centres (Clewlow, Sussman, & Balakrishnan, 2012; Lansky, 2013; Loomis, 2015). This also accounts for the time taken to check in and waiting in line at the airport security, which is effectively eliminated when boarding a train. However, from a strict time management perspective, HSR will work best when undertaking journeys with an endpoint ranging between 1 and 4½ hours (equivalent to approximately 150–900 km) (European Union, 2010).

Since the eruption of the COVID-19 pandemic, travel overall took an extensive dive. In many cases, the companies running these travel services are struggling to survive. For instance, Amtrak lost approximately 95% of its customers since March 2020, and expects to have lost 50% of its revenue in 2021 (Jiao & Azimian, 2021; Verma, 2020). Moreover, the "Acela Nonstop", a direct train from Washington, DC to New York's Penn Station introduced in September 2019, was suspended in March 2020 due to low ridership (Locke, 2020). The US Congress did inject US$1 billion in emergency funding in 2020, but in spite of this effort, the company continued to haemorrhage profusely (Mathews, 2020). From a political standpoint, echoed by some of the organisation's management, there have been ongoing efforts to sway the the opinion away from the contention that companies like Amtrak should be considered for-profit organisations, instead preferring to compare them to the postal service, where the objective is not profit but rather to serve entire communities (Broadwater, 2020; Verma, 2020).

Notwithstanding, there are many contentions against the HSR as well, and historically its implementation has often failed to deliver on its original expectations for numerous reasons (McArdle, 2019; Nash, 2015). For instance, when the Acela (formerly: Acela Express) was first developed by the US national rail agency Amtrak during the 1990s, it originally promised speeds capable of no less than 240 km/h (Dao, Wald, & Phillips, 2005). It finally entered service between Washington, DC to Boston, Massachusetts on December 11, 2000 (Middleton, 2001). However, new stipulations and security requirements were added, along with other various settlements, such as the demands that Acela be able to withstand impact from a freight train at speed without collapsing (Black, 2005). The original cost projection from 1996 would ultimately skyrocket by about 50%, from US$800 million (including 20 trainsets with six coaches each, along with power cars at front and rear) to a total of US$1.2 billion in 2014 (including the 20 trainsets plus 15 extra high-speed locomotives and the construction of maintenance facilities in Boston, New York, and Washington, DC) (Los Angeles Times, 2002; Phillips, 2004). Also, Acela had to share tracks with traditional, non-HSR trains. This would lead to congestion and costly designs to accommodate both train types. Moreover, the infrastructure in and of itself was timeworn, and many of the existing bridges and tracks would not sustain a 562.5 tonne (620 US ton) trainset charging at 240 km/h (Mortimer, 2020).

Adding to these problems was the fact that HSR trains are considerably noisier than traditional trains. Along many stretches there were people living in close proximity to the tracks, with homes built decades prior, long before HSR noise considerations had been an issue. To this end, local regulations were imposed to limit Acela's speed through some for these neighbourhoods, and adding to this was the federal government's imposed speed restrictions over ageing infrastructure (Mortimer, 2020). At the end of the day, this all meant that Acela, at an average speed of 132.3 km/h, would take approximately 2 hours and 45 minutes to traverse Washington, DC to New York, a speed considerably slower than even the fastest traditional trains had decades earlier (Amtrak, 2019; Mortimer, 2020). In effect, Acela became an aesthetic improvement over its predecessors, but failed to deliver anything close to its originally marketed speeds. It should be noted, however, that research has been conducted with the aim of reducing the noise levels for HSR trains, with some studies even looking at the possibility of building greater portions of the tracks on bridges rather than subgrade on ground (F. Xu, 2018).

Nevertheless, HSRs are known to be notably slower in Europe and the US as compared to Japan and China. For instance, European HSR corridors start at 201 km/h and reach 355 km/h. Time and money constraints in building the railways are invariably the most common causes for this (Frost, 2010; Levitz, 2010). The Japanese HSR train model, Shinkansen is, as of 2014, developing a new model called "Chuo Shinkansen" aimed to connect Tokyo and Osaka with a projected 2045 launch date with a maximum speed at 505 km/h (G. Li & Huang, 2020). Even though current Chinese and Japanese HSRs reach the same velocity as their Western counterparts, some railways opt for the maglev trains, capable of reaching up to 435 km/h (though they average considerably less in operation) (Frost, 2010). The maglev is essentially a competing system, which rather than a conventional railroad track, uses two sets of magnets, whereof one repels and pushes the train up off the track, and the other one moves the elevated train forward (Weakland, 2019). One notable example of the maglev is the Shanghai maglev train (Y.-L. Xu, Wang, Li, Chen, & Yang, 2019). However, the maglev requires a unique railroad and is incompatible with the existing railway system that exists across the greater part of the world, while also consuming more energy and maintaining higher operating costs than the HSR (Vuchic & Casello, 2002).

The point to be made about HSRs is that while they may be effective for shorter distances, they are still expensive to build and often turn out to be far more costly than initially anticipated due to circumstances uncovered along the way. To exemplify, in June 2021, the prospective Swedish endeavours to build a HSR were reported to cost a total of almost US$841 million (SEK 7 billion) per 10 km, as opposed to the initial estimation of US$660 million (SEK 5.5 billion) per 10 km (Dagens Nyheter, 2021). The main reason for this was that the routes would use tunnels and viaducts to go through and over obstacles rather than around them, much in the same manner as Shinkansen also does (Takemiya & Bian, 2007). Beyond the actual upgrades to the trains themselves, such as for purposes of accommodating for various safety requirements (as previously mentioned), there are several other ancillary costs as well. For example, the trains in and of themselves are financed by the railway company, while the railroads are generally funded, directly or indirectly, by an infrastructure company that is part of a government managing authority. This will incur the railway company *direct costs* for the trains per se, but also added *indirect costs* in fees for using the railroad. Also, pre-existing and surrounding infrastructure will often make it difficult, if not impossible, for the HSR trains to actually deliver the speeds it is capable of for the entire distance. In a worst-case scenario, the trains would even keep the same, or even yet, slower speeds than traditional trains, which would, in effect, invalidate its entire raison d'etre.

Moreover, new railroad systems will claim extended construction time (assuming that new, customised railroads are indeed built) and will, in certain places, impact adversely on the local wildlife, especially in countryside areas as well in places closer to residential areas due to the noise and vibrations produced by the trains (Hanson, 2008). However, beyond that, as we have learned from the aforementioned Acela case, HSRs are not profitable in times of pandemics, and while there are ongoing political discussions on changing the attitudes and perceptions of what it means to run a train service, one can expect to see many HSR services cease or diminish its operations in times of low ridership.

Of course, this is not exclusively true only for HSR trains, but also for other means of transit services as well. Still, upgrading to a HSR entails a massive, long-term investment which requires potential of profitable revenue and a high, steady and predictable volume of ridership. The social distancing culture brought forth by COVID-19 has indicated that passengers feel less comfortable in sitting together with large crowds for extended periods of time, and especially not if the travel times saved are considerably less than what it originally promised to be and compared to what other alternatives can offer. Admittedly, HSRs, along with trains by and large, still hold the upper hand from a strictly environmental perspective inasmuch that they run on electricity.

5.3 Electric Aircrafts

The previously mentioned roadable aircraft may, in essence, theoretically work as a form of electrified aircraft in and of itself. Nevertheless, it is a future development that is yet to be further developed over many years, or decades, to come, and its development is, much like with most other contemporary EVs, stymied by the capacity limitations of extant batteries. Furthermore, it is not a mode of transportation that is suited for transporting larger volumes of passengers. To this end, the development of electric aircraft has recently seen some rapid developments and is argued to have the potential of becoming the "third revolution" of aircraft technology, following the invention of heavier-than-air flight and later, the jet engine (Desmond, 2018). While prototypes of electric flight have been around since the 1970s, recent developments have begun to experiment with various technologies, such as hybrid power and ion winds etc. (P. E. Ross, 2018; Taylor, 1974; H. Xu et al., 2018).

The civilian aircraft industry saw an average increase in productivity of 3.2% during the period 1972–1991 (Kronemer & Henneberger, 1993). The corresponding figure for the period 2009–2018 was 3.5% (Sobolev, 2020). As the airline productivity continues to increase, there is a need to: (1) reduce emission, and (2) ensure that there is capacity to meet the increased overall demands. In this, electric aircraft could play an instrumental role. Already now, there are a number of electric aircraft models in development, with anticipated certification dates spread throughout the 2020s. One example is the Harbour Air ePlane, a seaplane with a capacity of six passengers and a flight range of 160 km per charge (Charpentreau, 2019; Gierulski & Khandelwal, 2021). Another example is Eviation Alice, which is expected to carry a maximum of nine passengers (plus two crewmembers) with a flight range of 815.88 km per charge, enough to cover distances such as Stockholm to Berlin (810.27 km), London to Frankfurt (637.34 km), or Los Angeles to Las Vegas (367.47 km) (Baumeister, Leung, & Ryley, 2020; Eviation, 2022). A third example is Heart Aerospace's ES-19, which promises a capacity of 19 passengers and a flight range of 400 km per charge (Baumeister et al., 2020).

Admittedly, the development of electric aircraft has been slower than it has been for EVs. This is chiefly due to the fact that the battery cells needed are much too heavy and cumbersome for aircrafts since batteries offer only a negligible amount of energy compared to aviation fuel. In comparison, lithium-ion batteries including packaging and accessories provide 160 Watt-hour per kilogram (Wh/kg) while aviation fuel provides 12,500 Wh/kg (P. E. Ross, 2018). Given the energy needed to power an electric aircraft, it is currently not feasible to consider large-scale aircrafts such as those tantamount to the Boeing 747 etc. but rather for smaller scaled aircrafts.

There are, of course, other types of batteries or rechargeable energy sources as well, such as fuel cells, ultracapacitors, microwaves and even solar cells, but none have seriously rivalled traditional aviation fuel in terms of Wh/kg (Kuperman & Aharon, 2011; Sumi, Dutta, & Sarker, 2018; H. Xu et al., 2018). For this reason, many electric airlines will not be able to do away with traditional fuel together, at least not during longer flights. Electric aircrafts used for that purpose should thus chiefly be viewed as mitigating negative environmental effects rather than eliminating them, at least with the currently available technology. This effect can be reinforced through the implementation of biofuel. The problem with biofuel, however, is that it is expensive and only produced in a comparatively smaller scale than conventional fuel. Hence, there would be a need for further policy instruments to increase the incentive of producing biofuel and reducing the manufacturing costs or else the future of biofuel is left to the discretion of those customers who are willing to pay extra for it. Developing hybrid aircrafts by combining biofuel with electricity could be a way to mitigate the disadvantages found in opting for exclusively for either of the two options (Hannula & Reiner, 2019; Moore et al., 2017).

Still, strictly electric-powered aircrafts do carry one other chief advantage over conventional flights, namely their markedly lower operational costs and lower maintenance needs for their electric engines as opposed to jet engines and turboprop (turbine) engines (Hoelzen et al., 2018; Ydersbond, Buus Kristensen, & Thune-Larsen, 2020). They are also anticipated to requite much shorter runway distances for take-off and landing than conventional airplanes (Mahvelatishamsabadi & Emadi, 2020; Smith et al., 2012). More than that, they are notably energy efficient. A global fleet of all-electric aircraft serving all flights up to a distance of roughly 741–1,111 km would require an equivalent of 0.6–1.7% of the worldwide electricity consumption in 2015 (Schäfer et al., 2019).

However, as previously mentioned, the electric aircrafts' most notable restriction is the limited distance they are able to travel. Another drawback is that the current electric aircraft prototypes are markedly slower than conventional jet planes. For example, Eviation Alice has a flight speed of 440 km per hour, a little more than half of that of an Airbus A320's lower-end speed at 800 km per hour, but on the other hand, approximately twice the speed of that of many conventional long-distance trains around the world (Dominguez, De La Morena, Telleria, & Azcona, 2020; Endemann, 2019; Sidairi & Rameshkumar, 2016).

The electric aircraft may also find itself rivalled by other initiatives of sustainable aircrafts. In fact, some contend that in the distant future, the solution is not even electric aircrafts at all, but hydrogen-powered planes (Khandelwal, Karakurt, Sekaran, Sethi, & Singh, 2013; Petrescu et al., 2020). Other forms of hybrid solutions have also been explored, such as the "hybrid wing body", or "blended wing body", in which the wing blends seamlessly into the body of the aircraft, making it particularly aerodynamic with the added ambition of dramatically reducing fuel consumption, noise and emissions (P. Li, Zhang, Chen, Yuan, & Lin, 2012; Lyu & Martins, 2014). One particular concept model is known as the "N3-X2" and would use a number of superconducting electric motors to drive the distributed fans to reduce fuel consumption, emissions, and noise, while its electric fans would be powered by two wing-tip mounted gas-turbine-driven superconducting electric generators (Felder, Tong, & Chu, 2012). However, these types of aircrafts currently exist as theoretical concepts only.

Another example is SE Aeronautics' prospective SE200 series which promises a non-stop range of roughly 17,000 km, with a capacity for up to

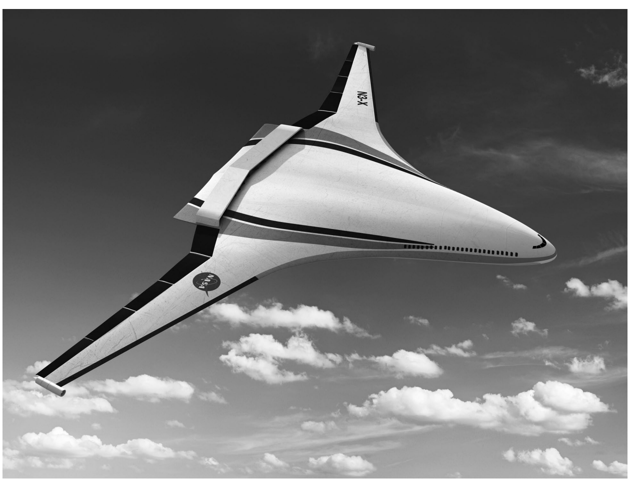

Image 5.4 NASA concept art of a future aircraft known as the "N3-X".
Source: NASA, Public domain, Wikimedia Commons.

264 passengers (Niknam, 2021). The SE200 series also promises to reduce fuel consumption by 70% and CO_2 emissions per seat kilometre by 80%, while cutting the total aircraft block hour cost by half and doubling its lifespan. This would be made possible thanks to a light tri-wing configuration design to enhance lift over drag, resulting in short take-off and landing (STOL) capabilities and extremely long flights. Fuel would be stored in self-sealing bladders on top of the fuselage rather than in the wings (Reichmann, 2021).

If turned into reality, initiatives such as the SE Aeronautics SE200 could most certainly have the potential to disrupt the electric aircraft, though the electric aircrafts have the advantage of already existing as a flyable aircraft. However, it is important to remember that during its early days, electric aircrafts will only be able to take very few passengers per flight. For this reason, they will likely be best suited for shorter routes between smaller to medium-sized cities generally trafficked with smaller volumes of passengers. Naturally, there need to be added incentives in making the electric aircraft attractive if it is to develop and improve further. A problem is that in some countries, existing legal frameworks have potentially stymieing effects on incentivising travel with electric aircrafts as opposed to other means of travel. For instance, as of April 1, 2018, Sweden introduced an air passenger tax for commercial flights holding more than ten passengers for the purposes of reducing greenhouse gas emission (Larsson, Kamb, Nässén, & Åkerman, 2018; Swedish Tax Agency, 2020). This tax affects airline passengers regardless of aircraft type, including electric aircrafts. Ironically, however, electrical aircrafts (assuming they are not of a hybrid biofuel model) carry no such emissions whatsoever (Bernardi, Giarola, & Bezzo, 2012; Schäfer et al., 2019).

5.4 Autonomous Trains and Aircrafts

Autonomous devices such as ATO (mentioned previously in this chapter) are still less commonly applied to the HSR as opposed to the urban passenger railways, although a signalling system supporting GoA 2 does exists for the German *Intercity Express* (ICE) high-speed line (Brandenburger, Naumann, & Jipp, 2021; Brandenburger, Thomas-Friedrich, Naumann, & Grippenkoven, 2018). Model CR400BF-C of the "Fuxing Hao" trains, capable of top speed of up to 350–400km/h, was at the time of its introduction in late 2019, reported to be the world's first HSR service capable of driverless automation in commercial operations (Seetao, 2021; Wang et al., 2020; Wong, 2020; Yeerkenbieke, Chen, & He, 2021). The inter-city railway was originally designed to provide a high-speed train to link Peking (Beijing) and Zhangjiakou for the 2022 Winter Olympic Games (Yeerkenbieke et al., 2021). Although the specific GoA was not publicly disclosed at the time of its announcement, the fact that there is a monitoring driver on board at all times and that at least some stations seemingly lack a platform screen door, would indicate that the CR400BF-C has a GoA 3 (at most) rather than a GoA 4 (Wong, 2020).

Autonomous aircrafts, or pilotless planes, have already existed for some time now, primarily in the form of unmanned drones. While autonomous aircrafts have been given less widespread attention in the media than AVs, the development on turning autonomous aircrafts into modes of transportation for humans and goods is progressing steadily. In fact, a 2019 study by the engineering simulation company ANSYS showed that 70% of consumers are prepared to fly in autonomous aircraft at least once in their lifetime (Nichols, 2019).

It was reported in 2020 that the San Francisco-based aerospace and autonomous technology company, Xwing, had performed numerous passenger-carrying autonomous take-off to landing flights in its modified Cessna 208B Grand Caravan, which was described as a first in aviation with this category of aircraft (Barber, 2020; Nichols, 2020; Pasztor, 2020). At bedrock, there is a strong case for introducing autonomous means of air travel. For instance, according to reports from the Federal Aviation Administration, the US airline industry is dealing with a 30% reduction in qualified pilots and has been doing so over the past 30 years (Federal Aviation Administration, 2022; Nichols, 2020).

The surge in logistics and fulfilment, and particularly so, the demands for next-day deliveries, have added inexplicable burdens to the air shipping ecosystem. This problem was even more so accentuated by the COVID-19 pandemic and the ensuring global travel restrictions, which dealt a heavy blow to all airline industries. In this way, autonomous flights would serve not only to remove flight staff from the risk of being infected by being physically exposed to the virus, but also as a means of streamlining operations (Dobre, 2021; Pallini, 2020). By retrofitting existing aircrafts, it is possible for remote operators who work with air traffic controllers to ensure safety throughout the flight monitor operations from the ground. This, in turn, would centralise human resources, which could cut costs by approximately 20–30% (Nichols, 2020). Thus, pilots would be replaced by ground-based controllers, similar to military drone operators. Their function would be to oversee the flight and adjust its autopilot at the direction of air traffic control. According to this notion, the aim would be to automate away as much as possible, including the take-off, the landing, and thereby also avoiding any and all collisions in between cause by "the human factor", while at the same time always keeping a human "in the loop". Although airline fatalities have decreased markedly since the early days of flying, pilot error remains approximately three times more likely to cause a crash than a mechanical failure, which would propel the argument of those seeking to automate piloting (Easterbrook, 2018). Rather than overseeing one flight per day, pilots would be able to manage multiple flights in short succession or possibly even multiple aircrafts at a time. The idea boils down to keeping more planes in the air but with fewer pilots, thereby cutting much of the staffing costs, a salient issue as pilots retire and training new ones require long and expensive schooling (Barber, 2020; Derek & Julio, 2021).

Nevertheless, AVs are for all intents and purposes still very much in a nascent stage, and only an "augmentation" to existing vehicles. The technology would need to be perfected over many years to come, and once available, existing vehicles would need to be retrofitted to take advantage of the autonomous capabilities. To the point, the modes of transportation would still need to be developed and refined and an ongoing debate has for long been whether or not one should invest in the railway or in aircraft. Both of these options would offer great future possibilities should one choose to invest and develop these technologies further.

5.5 The Hyperloop

The Hyperloop was first mentioned by business magnate and billionaire Elon Musk in 2012 (Armagan, 2020; Pensky, 2012). It is a proposed mode of passenger and freight transportation that would operate in a sealed tube, or tunnel system with low air pressure (Stryhunivska, Gdowska, & Rumin, 2020). This tube would then be trafficked by a pod which would be able to travel in a manner that is essentially free of any type of air resistance or friction (Michelberger, Plavec, Pyrek, & Graf, 2022). Musk once expressed the rationale behind the Hyperloop in the following way (Griffiths & Elfmar, 2013, p. 220):

> *What you want is something that never crashes, that's at least twice as fast as a plane, that's solar powered and that leaves right when you arrive, so there is no waiting for a specific departure time.*

Theoretically, the Hyperloop would be able to transport goods and/or people at hypersonic speeds while at the same time maintaining an energy consumption that does not exceed that of the extant HSR systems. If successfully developed and implemented, the Hyperloop would be able to considerably reduce travel times over distances of under approximately 1,500 km as compared to train and airplane travel. According to the original projections, the Hyperloop would, for example, allow travels across a 560 km route at a speed of 1,223 km/h, corresponding to approximately 35 minutes of travel time (Gupta et al., 2020; Negash, You, Lee, Lee, & Lee, 2021). If successful, it would be able to transport 15 million people from Los Angeles to San Francisco on a yearly bases (round trip) (Gupta et al., 2020). So far, the Hyperloop exists in a decidedly limited capacity. Musk's company SpaceX built roughly 1.6 km subscale track for its pod design competition at its headquarters in Hawthorne, California in 2016 (Aroska, Naik, & Tiple, 2019). On November 8, 2020, Virgin Hyperloop conducted the first human trial at a speed of 172 km/h (107 mph) at the Virgin Hyperloop's "DevLoop" test track in the desert outside Las Vegas, Nevada (Hu, Long, Zeng, & Wang, 2021; Matthews, 2021).

The anticipated total cost of the Hyperloop was reported to be under US$6 billion for two one-way tubes and 40 capsules (Rajendran & Harper, 2020). The reason it could be built so much cheaper as opposed to a railroad is that the tubes can be built above ground on pylons in prefabricated sections that

Image 5.5 Concept art depicting the Hyperloop.
Source: Neuhausengroup, Creative Commons.

are later dropped in places and joined together (Gupta et al., 2020). Proponents argue that amortising this capital cost over a period of 20 years and adding daily operational costs would render a total of US$20 plus operating costs per one-way ticket per Hyperloop passenger (Mahajan, Bankar, Patil, & Mahajan, 2019). However, there is some scepticism regarding the estimated costs, with some critics contending that the actual cost would be considerably higher, arguing that a more realistic price for a one-way ticket would rather be closer to US$1,000, based on a projection 840 riders per hour, and a construction cost closer to the vicinity of US$100 billion (Brownstein, 2013). Indeed, infrastructure remains a problem, since it would also require political support in order to build the necessary infrastructure on a wider level. Also, commercial implementation is still far off. It was originally anticipated that Virgin Hyperloop expected the first safety certification to be passed in 2023 (though later revised to 2025), with the Hyperloop being introduced for commercial use by around 2030, or even in 2027 at the earliest (Espindola & Wright, 2021; R. Ross, 2021; Zackrison, 2020).

6 Conclusion

The aim of this chapter was to explore how infrastructure and travel within and between smart cities may be affected by pandemics such as COVID-19 and what can be done to improve travelling during pandemics in the future.

Action 1: Upgrade the Road Infrastructure

Infrastructure and travel needs to be utilised in a "smarter" way so that it has the ability to reduce large clusters of people involuntarily congregating at the same place while travelling. Smart transport design is already beginning to be implemented across various smart cities and we can undoubtedly expect to see more of it in many other smart cities in the future. Granted, many of the solutions discussed in this chapter would require extensive investments and redesigns of the existing road grids, but in many cases, the opportunity cost of not addressing the extant problems would be much higher. Also, it is important to bear in mind, that the more vehicles and roads become electrified, the greater the need of having adequate energy resources in place to ensure the steady flow of power. Moreover, some of the discussed technological solutions would not be as invasive as some of the others. For instance, developing technology that supports real-time navigation would alert motorists to potential traffic disruptions that will likely cause delays, while assisting them in finding the fastest alternate route. Currently, drivers are resorted to using navigation apps for the smart phone to receive a similar service, but these do not always account for sudden changes on the roads (at least not without the hassle of having to switch apps, and in some countries operating a mobile phone while driving is illegal). Developing smart-parking apps would provide the possibility to direct motorists directly to available parking spots, eliminating unnecessary time and frustration spent on relentlessly circling city blocks in search for an available parking spot, thus also reducing the risk of forming queues and clusters of people.

ITS can be an aid to help people make better informed decisions regarding what route to pick, thereby spreading out traffic more evenly and thereby mitigating the traffic congestions. In this way, opting for ITS solutions rather than building new roads has the potential to provide for a solution that is more cost-efficient, less-invasive and speeds up the traffic flow, while being up-and-running much quicker than a new road or even a lane would, although additional specific research into this matter would be needed. Smart roads also have the potential of generating energy, which will help compensate for some of the energy needed to uphold the "smart systems".

There will also need to be a "smarter" system for applying "congestion charges", in the cities where these exist, or will be introduced. The charges need to be based on the de facto traffic congestion that is in the city at that particular given time, rather than on approximations of historical data. This would allow for a system that is fairer and more effective in its implementation, as it would circumvent the problem of the ensuing bottlenecks that occur right before and after peak hours when drivers are attempting to circumvent the higher road fees.

Action 2: Introduce "Smarter" Public Transit

By the same token, using "smarter" information systems in public transit, will allow for people to make better informed journeys before deciding on what route to take. This will be the most pressing course of action for intracity travel. Reducing the need for physical contact with various elements, such as turnstiles, ticket vendors etc. will be a way towards reducing the spread of viruses and germs. Automating train services may also be a way towards further reducing points of contact for train staff, while also ensuring a smooth and steady flow of traffic that operates under a harmonised and predicable system. However, this also comes at the added cost of additional layoffs amongst train staff, and there is still an issue of gaining the trust of the population in a system that is fully, or near-fully, automated.

The continued use of cash would have to be a trade-off. While cashless options should be readily available and encouraged, it is important that it does not come at the expense of public accessibility. Hence, the option to make purchase with cash should remain for those who need it (or during instances where digital payment is not possible), but the cashless alternatives should be given emphasis. However, lawmakers should mandate the possibility for denizens to continue using cash in order to ensure that cash-based options are not removed by companies for essential services. A more stringent classification and better organisation of micromobility devices (such as clearer instructions where one is and where one is not allowed to use them) could help reduce further congestion in the public transit systems, albeit with a slightly increased risk of automotive accidents involving micromobility devices. Also, there is a risk of added clutter of unused micromobilitiy devices around the cities creating hazards to accessibility, safety and the environment, unless the city adopts a clearer set of instruction and rule enforcement of where to put such devices (most prominently applicable to shared electric scooters) when they are not in use.

Action 3: Transparency about HSR

For domestic, or shorter-distance international travel, there are currently multiple developments in different sectors. While the roadable aircrafts are still a long way off (even for local transport), the popular discourse has been whether to opt for trains of airplanes, and more specifically between HSRs and electric aircrafts. While HSRs carry an advantage in sheer capacity with the added ability of transporting passengers directly to the city centres, they also carry extensive investment costs with multiple aspects to consider, and rarely are they able to provide the maximum speed capacity consistently throughout the entire stretch. For that reason, they are best suited for travel distances shorter than 4½ hours and for destinations that are frequently trafficked by larger volumes of people. The train also has the added advantage of being able to space out passengers throughout the wagons, and it is for obvious reasons essential that this is done whenever necessary. HSR will be effective on routes with heavier traffic, where larger quantities of people and goods will need to be transported on a frequent basis. Nevertheless, it is not a universal solution for all types of intercity transport. Furthermore, there needs to be a more realistic discussion in regard to what HSR can offer and what it cannot. Many proponents will try to oversell the concept of HSR for political reasons (often citing environmental arguments). However, the limitations of HSR, as well as its ancillary costs and the factors impeding on its purported top speed, will need to be communicated in a candid, upfront and transparent manner and there will need to be in-depth cost/benefit analyses conducted on the suggested routes prior to undertaking investments into building/redesigning infrastructure for HSR.

Action 4: Reimagine the Electric Aircraft Industry

Electric aircrafts, on the other hand, have very low operating costs compared to conventional airplanes. Their main restriction is their limited capacity, both in size and travel distance per energy charge. Its lower speed as opposed to other aircrafts is essentially a matter of perspective. Rather, it should be contrasted to other, non-aircraft based modes of transportation, such as by train, bus, car or boat, in which case the travel speeds are still quite favourable. Also, the smaller number of passengers means that the electric aircrafts could potentially be a favourable option for inter-city travel during pandemics and government-imposed limits on the number of people allowed to occupy a given space at a given time. There is much development potential in electric aircrafts, given that batteries and other energy sources are being constantly developed and augmented. There is potential of further developing hybrid planes that use both electricity and biofuel. By reimagining the airline industry and what the future of aircrafts could be like, current political attitudes towards flying could turn and more resources could be invested in developing the electric aircraft further. The technology already exists, but is at this point in time heavily under-dimensioned both in terms of physical capacity and battery efficiency.

Concluding Remarks

From a sustainable point of view, it is important that the electrification of roadable vehicles continue, which, by extension, also places greater emphasis on the need of securing enough electric power in the future. Beyond this, both trains and electric aircraft need to be powered as well. What is true for both the HSR and the electric aircraft is that there is a need for political incentivisation as well as a need to review laws that are unfairly affecting these modes of transport in an adverse manner. For instance, electric aircrafts need to be classified as "environmentally friendly" and exempted from any form of carbon emission-associated tax/fee etc. Above all, there is need to redefine the services these modes of transportation carry, inasmuch that the services are provided in a way that is more akin to the postal service and less on the basis of how profitable it is during a pandemic. It is important to remember that there will always be a need for travel services, and assuming that there is indeed a demand for the service, profitability will most certainly pick up once the pandemic has passed.

Note

1 For a more detailed discussion on SMRs and sustainable energy resources in general, please refer to *Chapter 10: Sustainability.*

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6 Welfare and Healthcare

The View on Health and Wellness in the Future

1 Introduction

Welfare and healthcare is constantly evolving as it is an area that is generally readily receptive towards new technological advancements. As per the National Conference of State Legislators, smart cities seek "to improve quality of life, economic opportunity and security for those who live in cities and surrounding areas" (Ferreira, 2021, p. 34). While the term "welfare" is a broad concept, it primarily refers to a type of government support that is intended to ensure that the denizens are able to secure their basic human needs such as food and shelter. This is particularly pertinent in light of the expansion of smart cities. According to the 2004 United Nations HABITAT report, it is estimated that by the year 2030, 60% of the world's population will reside in megacities, i.e. cities with a population exceeding 10 million people (Gülseçen et al., 2021). How all those people live, and what their lives will be like, is contingent on the actions taken by political leaders today and in the coming years. Moreover, it is in this context nearly impossible to dissociate the connection that welfare has with health. Without adequate food and shelter, the health begins to suffer.

In terms of healthcare, a smart city is a community where denizens can engage with smart services specifically designed for the purposes of improving health. Smart cities have the advantage of already having undergone a digital transformation with an omnipresent Internet of Things (IoT) infrastructure, which enables denizens to engage with various smart services designed to improve their health. This includes technologies such as artificial intelligence (AI), 5G (and its successors) and smart cameras etc. Health benefits are also found in innovative strategies and design. In smart cities, there is also the potential to utilise sensors that can analyse parameters associated to temperature, pollution, humidity and power grid status and so forth in order to assess various predictors of the city's denizens' health conditions at any given time (Chauhan, Mishra, & Joshi, 2021; Pérez-Roman, Alvarado, & Barrett, 2020). The possibility to connect the ever-growing plethora of health-related data, along with health and human services integration, is undoubtedly one of the smart city's greatest potential contributions in terms of improving people's

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health. Still, the full impact of a smart city's potential is only brought to fruition if interoperability can be secured across core health, human services and non-health sector systems. This includes public safety, occupational safety and health, environmental health, social services, emergency services and transportation. Hence, the aim of this chapter is to explore how smart city technology is transforming the nature of welfare and healthcare with new, innovative applications of technology, and how this may develop following a large-scale societal disruption such as COVID-19.

2 If Smart Cities Are so "Smart" – Why Are There Still Crises Following Pandemics? Contemporary Insights into the Welfare and Healthcare Response

Comparing the cities' response towards flu pandemics between that of the great influenza in 1918 (the "Spanish flu") and the COVID-19 pandemic of 2020, it is clear that the world is a radically different place. Prior to the start of the COVID-19 pandemic in 2020, the contention was that the cities would be much better prepared for a future flu pandemic given the fact that the world had turned into a much more globalised place and that the barriers of time and place that impeded earlier emergency responses had essentially been all but torn down (Kickbusch & Sakellarides, 2006).

Bill Gates raised a thought-provoking point in this regard when he posited that society was well-prepared for the next war, but not for the next pandemic (Crossan, Seijts, & Gandz, 2016; Osterholm & Olshaker, 2017). He argued that there would need to be a medical reserve corps that could house large resources of human resources with the training, background and expertise that would be prepared to be dispatched swiftly. In other words, there would need to be a medical service with the same readiness, resources and alertness as that found for military endeavours, also on a local level. Much like previous pandemics, such preparedness was not found ahead of the COVID-19 pandemic.

This raises an interesting question, if science already claimed preparedness before the eruption of COVID-19, how come so many cities failed to protect the health of its denizens (Söderström, 2021)? Part of the answer rests in the obvious fact that cities are not decision-making units per se in most matters pertaining to the individual's health. As will be extrapolated upon later in this chapter, this makes the need for individuals to gain the possibility to take greater action over their own health all the more pressing. Still, what of the cities and their role? Kickbusch and Sakellarides (2006) discuss the existence of two types of cities: the *flu city* and the *smart city*. In the case of the former, the flu city, there is only a narrow focus on the medical condition and the medical response. In the latter case, the smart city, there is an emphasis on the types of innovation that are of value to the city and its denizens that lie far beyond a public health emergency. The point of departure is that although viruses act in a "smart" manner, humans have the potential to be even smarter, assuming that they respond with all the technological and social ingenuity that communities have to offer. Thus, the key is to change society's mind-set and shift from "threat" to "ingenuity". They express this in terms of the "critical triangle" which they define in the following manner (Kickbusch & Sakellarides, 2006, p. 85):

> The critical triangle consists of a unique and dynamic interface between three components: knowledge, values and innovation. If we want to be prepared for a major flu epidemic we must understand not only the virus and how it spreads but also cities and how they function, organizations and how they operate, communities and how they relate, and individuals and how they make choices.

In preparing for and following the development of the 2009 "H1N1" flu pandemic (commonly known as the "swine flu pandemic"), this set of notion was adopted to analyse the "social response" to the pandemic threat (Sakellarides, 2020). Nevertheless, the aftermath of the H1N1 flu pandemic proved to be hostile to innovative thinking. The H1N1 virus was partially "known" already and the disease incidence was akin to that of a moderate seasonal flu. This led to community perceptions that the approaches and responses taken in preparation for the pandemic were exaggerated. The procurement of vast amounts of the antiviral medicine *Oseltamivir* (sold under the brand name "Tamiflu") was harshly criticised and there was only a limited runtime for the vaccination programme for the H1N1 virus. Still, the traditional public health emergency model would, by and large, remain unchallenged following this experience (Sakellarides, 2020).

Smart technology has the potential to do much to assist the conventional healthcare as well, i.e. beyond the useful statistics collected by various devices from denizens who have volunteered their consent. For instance, future smart technology may enable path planning for healthcare vehicles (e.g., ambulances or self-testing kits) and provide AI-powered administration, prescription, drug safety and surveillance in urban hospitals (Ghazal et al., 2021; Munawar et al., 2021). It should also be noted that modern technology can improve the viability of living in certain communities that are more exposed than others to various forms of air impurities. For instance, sometime in the mid-2010s, Dutch inventor Daan Roosegaarde designed a 7 metre (23 feet) experimental air purifying tower that vacuums up smog, filters the bad particles and releases clean air (Raveendranathan, 2019).

In 2016, this tower was erected on an experimental basis in northeast Peking (Beijing), China, which is known for its extensive air pollution (Smedley, 2019). The tower, with an exterior resembling a metallic Venetian blind, was designed to scrub roughly 30,000 cubic metres of air every hour by means of positive ionisation, equalling approximately the volume of 12 Olympic swimming pools (Burki, 2019). Two years later, in 2018, a similar initiative was launched in the Shaanxi province capital, Xi'an, only this time

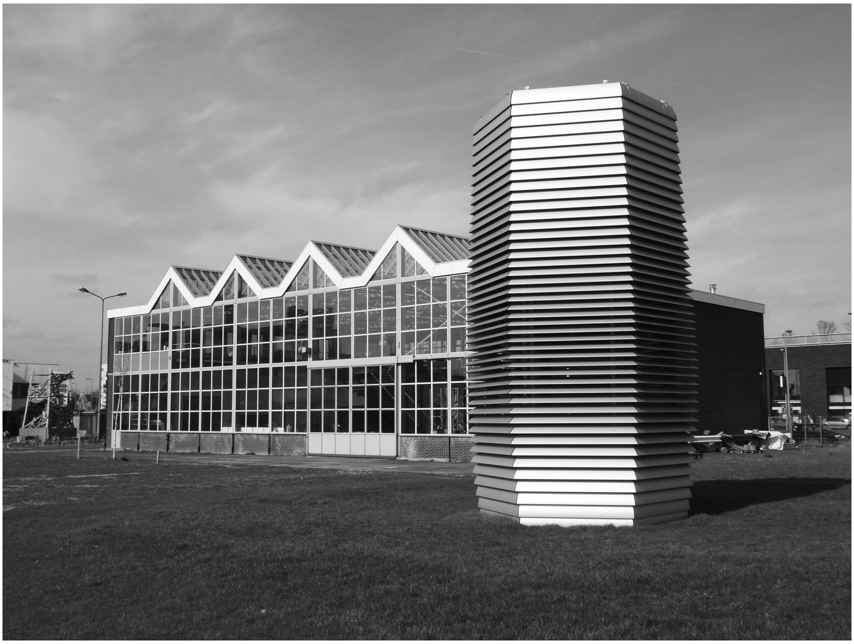

Image 6.1 Daan Roosegaarde's filter tower for cleaner air.
Source: Bic, Wikimedia Commons.

the tower measured 100 metres (328 feet) and boasted a filtration capacity of 8 million cubic metres of air per day (or 333,333.3 cubic metres per hour), and was dubbed "the world's biggest air purifier" by its operators (Chandrappa & Das, 2021; Raveendranathan, 2019). It subsequently underwent testing by researchers at the Institute of Earth Environment at the Chinese Academy of Sciences to quantify its effectiveness, with the trial operations indicating an approximate 80% air filtering efficiency (Chandrappa & Das, 2021; Raveendranathan, 2019). Initial testing has also shown that air purifiers have had an advantageous effect on combating COVID-19, with the Hong Kong-based company Aurabeat having created an indoor air purifier able to eliminate over 99.9% of the COVID-19 virus present in the air (Miao, 2020; Tzoutzas et al., 2021).

Israeli historian and futurologist Yuval Noah Harari noted that several countries in the Asian region have made use of tracking applications to monitor the population while also prescribing to a different set of attitudes towards disease transmission and relying more on "extensive testing, on honest reporting and on willing co-operation of a well-informed community" (Harari, 2020, para. 14).

Moreover, a team of Italian healthcare researchers referred to the contemporary pandemic, patient-centred healthcare found in the Western healthcare systems as inadequate and called for it to be replaced by community-centred care, contending that pandemic solutions are required for the entire population, not just the hospitals (Nacoti et al., 2020).

Hence, much of the contemporary research calls for a reform of the healthcare system's approach towards pandemics. There is an agreement that technology could, and should, play an important role, but then what approach can digital technology offer in terms of safeguarding the public health? An important point of departure is to understand what "health" is and how we can come to see it in a new way given the development of smart cities.

3 Philosophical Approaches towards Health

Historically, the concept of "health" has received far less scholarly attention than matters relating to "disease" and "illness", which, in turn, effectively serves to describe the mere absence of wellness (Lee, Guillett, Murray, & Meeks, 2020; Reiss & Ankeny, 2016). What then signifies "health"? While it may seem straightforward to most people most of the time to answer whether they feel well or not, the concept of health is indeed far more convoluted than it appears at a first glance.

The naturalist approach would be to define "health" as a product of a functional biology (Ananth, 2008; Ayala, 2004; Méthot, 2015). This entails looking at what is seen as biologically natural and normal functioning for humans on a more universal scale, allowing for some categorisation such as age group, gender/sex etc. The naturalist argument is that healthcare should focus on discovering and illustrating the underlying biological criteria that makes it possible for us to identify and describe different diseases (Ananth, 2008; Reiss & Ankeny, 2016). A leading contention is the belief that health is essentially synonymous with the absence of disease, in which a disease is an internal state that restricts or impairs normal functional ability, along with some elements of environmentally induced conditions, such as dental caries etc. (Boorse, 1997, 2014). Specifically, health entails a shared set of judgement regarding what we deem that we should be able to do. In this sense, "disease" is the deviance from these abilities, or rather, our "social norms" (Margolis, 1976). Naturalists would argue that the definitions they use are not merely philosophical, theoretical or academic constructs, but that they mirror real-life usage of the terminologies commonly associated with disease and health in common language as well as among medical staff. The naturalists believe that their approach more adequately elucidates how particular conditions have come to be perceived differently over the course of history, since our values are not fixed constructs, but change/evolve over time as new knowledge and insight is made available to us. This would explain how concepts, such as homosexuality, were once considered an illness by society as well as medical professionals, but no longer is by the vast majority of countries around the world (Powell & Scarffe, 2019). This view is also able to accommodate for various culture-bound syndromes as well, such as sicknesses supposedly attributed to witchcraft in certain cultures etc., since health and disease, according to this view, is to a great extent contingent on the cultural understanding, or "norm", of what should and should not be (Bechtel, 1988; Powell & Scarffe, 2019).

However, a criticism of the naturalist view is that even though it largely relies on biological science to generate definitions of health and disease, these suppositions are contingent on the existence of a "natural state" of something that is clearly and objectively identifiable (Ereshefsky, 2009; Hare, 1986). The problem with this assertion is that there are no absolute standards that are universally applicable in biology, and no particular genes are the "natural" ones for a given population (Ereshefsky, 2009; Sober, 1980). Another objection towards the naturalist approach is the underlying assumption that biological fitness (such as survival and reproduction) is the goal of human life. Hence, medicine should, per this view, only concern purposes relating to biological fitness, such as analgesics (painkillers), antibiotics, contraceptives, etc., as opposed to other human goals and values (Lennox, 1995).

Rather, an often cited source for a more conventional definition of health is the Constitution of the World Health Organization (WHO), in which health is defined as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (Green & Tones, 2010, p. 9). As per this definition, "health" should not be regarded as merely the absence of disease, but rather as a positive state of well-being (though admittedly, the term "well-being" can be perceived in an ambiguous manner in and of itself). Even though the essentiality of the quality of life is frequently cited in the discourse regarding health, one may exercise some caution in applying the WHO's definition too liberally. The reason is that this definition seemingly also includes many other factors beyond the ones directly related to the health of the individual, thereby attributing potentially remote/peripheral aspects and making them pertinent to the individual sense of "well-being" (Reiss & Ankeny, 2016).

Should we instead, yet again, opt for a narrower definition of health, one may think of health as being the state which medicine seeks to restore. Thus, "unhealth" would be its counterpoint, since it would signify a state in which one falls short of being healthy, as opposed to being inflicted with an actual disease (Kass, 1975). Under this premise, there is no room for medical science to offer aesthetic surgery or elective terminations of pregnancy or any other procedure that does not, strictly speaking, aim to restore health. Health can also be identified in terms of the psychological and/or physiological capacities an individual has that allows him or her to pursue a wide range of goals and projects (Whitbeck, 1981). This approach is more of a hybrid approach inasmuch that it places biological capacities at the core of health, with the added proviso that such is only done as far as to help individuals to flourish and live their lives the way they wish to (Reiss & Ankeny, 2016; Whitbeck, 1981). In this sense, health concerns more than the absence of disease since, for example, one could have a high level of health while at the same time one could suffer from a particular disease condition.

On the flipside, another philosophical contention actually argues against equating health with any hint of normality, since the idea of a "norm" cannot be objectively defined by using scientific methods (Canguilhem, 1989; Elden, 2019). The contention is that while physiology does indeed concern the science of norms, scientifically-based medical approaches as such will still need to focus on other matters beyond the remit of "norms". This follows much in line with the beliefs held by French philosopher Michel Focault (1973), who held a clear distinction between that which is considered "normal" and that which concerns the pathological. The overarching rationale behind this approach is the desire to reveal how values are integrated into the epistemological framework that upholds the teachings of modern-day healthcare. The exception taken to the word "normal" is rooted in the understanding that "normal" signifies the conflation of two separate meanings, (1) the "usual" or "typical", and (2) the perception that something is the way it ought to be (Canguilhem, 1989). Hence, it is not possible for a purely scientific explanation or objective definition to exist that can explain the concept of "normal" in a way that one can apply rules from physiology analogously on medical practice. For that reason, we cannot, strictly speaking, define "health" as a concept either. Rather, health should be regarded as something that confers a survival value, or adaptability, within a given environment or under a given set of circumstances (Canguilhem, 1989). In simpler terms, it is the ability to fall sick and recover. By the same token, "disease", should be regarded as the lessening of one's tolerance for the impulses of the environment. According to this view, the emphasis on health, as opposed to normality, is perceived to enrich the debate of preventative medicine and, more generally, skewing the development towards a more positive notion of health (Tiles, 1993). According to the Israeli philosopher Havi Carel (2007, 2019), health should be seen as the lived experience of one's own body, rather than existing in abstract biological terms. According to her, one needs to apply a phenomenological perspective that accommodates for cases in which someone is ill in the biological sense, but otherwise healthy overall, such as in the case of a chronic illness.

Another, more extreme, school of philosophical thought contends that seeking concepts of disease is failed endeavour because, again, there is in biomedical sciences no underlying general conception of disease that is stringent enough to be analysed, and in that, different ideas of disease might be equally applicable within different contexts (Reiss & Ankeny, 2016; Schwartz, 2007). As such, it is held by some scholars that the ambition of finding correct definitions for "disease" and "health" are actually immaterial and acts constricting and counterproductive when it comes to making clinical decisions (Hesslow, 1993). According to this school of thought, the answer lies in whether or not a particular condition/state is desirable to its bearer, rather than whether an individual has an affliction or not. For this purpose, the term "malady" is preferred by the proponents of this school rather than terms such as "disease", "illness", "injury", "handicap", "dysfunction" and/or "asymptomatic conditions" etc. This is because a "malady" indicates that there is a condition present with the bearer and that this is irrespective of whether the cause is physical or mental (Clouser, Culver, & Gert, 1981; Reiss & Ankeny, 2016). This approach seeks to harmonise a range of different phenomena and typologies that would appear intuitively related. However, this would come at the expense of depending, at least in part, on a naturalist approach to disease since it assumes that there is an identified conception of what "health" and/or "illness" (or in this case, "malady") is, and what a supposed "natural state" is, albeit an individually constructed one. As such, this approach is susceptible to much of the same criticism that is otherwise commonly directed towards the naturalist proponents (Worrall & Worrall, 2001).

Yet, another school of thought proposes that one should avoid mentioning anything pertaining to matters such as "naturalness", "functionality", "normality" or any other type of "normative statements" (i.e. explicit assessments in regard to how certain conditions are valued or disvalued) while at the same time seeing the necessity of drawing up a clear distinction between physiological states and psychological states (Ereshefsky, 2009). This approach allows for more clarity in regard to conditions that could be classified as "diseases" without facing the controversy of needing to apply the term explicitly, while also forcing us to specify the relevant issues to make it possible to treat someone suffering from ill health.

In summary, there have been, and continues to be, a plethora of different philosophies that have debated the concept of health for a long time. The most prominent dispute concerns whether or not it is preferable to employ accounts that are seemingly more objective, generalisable and based on natural scientific traditions, or if health also needs to incorporate social and/or experiential perspectives (Reiss & Ankeny, 2016). It is extremely unlikely that the philosophical discourse will reach a definitional consensus on health any time soon, as the debate will likely proceed ad infinitum. What is more, is that none of the extant schools can satisfactorily account for all the angles to provide a complete and robust philosophical account that is equally valid not just as scholastic talking points, but also for practical applicability. While the premise of this chapter will not make any endeavour to favour any of the aforementioned philosophies, healthcare, as we know it, will need to be responsive to and helpful for actual clinical practices and individuals in need. In this sense, one could even contend that digital technology proffers an entirely new philosophy on the matter in and of itself, as it enables new approaches towards healthcare. The centrality of digital healthcare and wellness is the notion of autonomy inasmuch the individual user feels that they are taking pre-emptive and active care to ensure their own well-being, and that these steps are customised to fit their own individual way of life (Entwistle & Cribb, 2011). Thus, the issue of autonomy and customisability may become more accentuated variables to the philosophical debate on healthcare. Thus, one may actually contend that the digital transformation will prompt the need for a new philosophy regarding healthcare altogether, and particularly so in regard to the role of personalised data.

4 The Role of Personalised Healthcare in Smart Cities

The interconnectivities of IoT devices that permeate smart cities have enabled the agglomeration of many different kinds of data, both on a societal level as well as on an individual level. The healthcare solutions made available through smart cities entail innovative means to pre-emptively address health and/or wellness concerns. In this manner, it is fair to say that Big Data has, in fact, enabled a health paradigm (Pramanik, Lau, Demirkan, & Azad, 2017).

Modern technology has made it easier to treat and improve the health of city residents in recent years (Glaeser, 2011). Nevertheless, the health and wellness solutions developed can offer relief to an already over-burdened healthcare system that is currently facing an ever-increasing demand in light of the awareness brought forth by the COVID-19 pandemic. This is, in addition to other demands presented by continued urbanisation, such as an ageing population, climate change and overall growing healthcare expenses (Gu, Andreev, & Dupre, 2021; Phillips, Hickman, & Bhattarai, 2020).

Personalising healthcare is a possibility that has been propelled by the advancement of digital technology. In brief, personalised healthcare focusses on patient-centred healthcare, personalised health planning and patient engagement (Pérez-Roman et al., 2020). A literature study by Pacheco Rocha et al. (2019) found that extant scientific research supports different modes of personal health surveillance as a mean of promoting a healthy lifestyle. A concrete example in this domain include wearable devices, such as the "Quell device", which is a band patients wear around their upper calf, which leverages electric signals to stimulate the body to produce endogenous opioids from the body to inhibit the nerve signals that emit pain (Singh, Dixit, & Kaur, 2020).

What can the smart cities do to facilitate personalised healthcare? The first order of business is to ensure that the technological prerequisites are in place, such as adequate wireless Internet accessibility and adequate Internet speed. The cities can also collect and provide anonymised data for research into how personalised healthcare delivery systems are functioning and what needs to be improved (Schoonenberg, Khayal, & Farid, 2019). On a more advanced level, cities can introduce the use of digital twins (explained in further detail in *Chapter 8: Digitalisation*), which may serve to lower costs in patient monitoring, while also providing city planners with enough information to improve the denizens' lives. The information accumulated may also be useful in predicative management of the smart city (Rajarajan, Renukadevi, & Basim, 2021).

Moreover, the smart cities can also facilitate the introduction and the use of new types of technologies into the cities. Specifically, the future development and amalgamation of digital technologies such as AI and the aforementioned wearable medical technology devices, Big Data and IoT, have helped and continue to help the progress of various digital platforms, which, in turn, enable personalised, predictive and preventative healthcare analytics. These new developments in wellness have the potential to profoundly alter the way consumers perceive healthcare by moving from a curative to a pre-emptive approach (Kittles, 2012; Kuriakose, 2017). The digital platforms help promote patient empowerment all the while by challenging the roles and functions traditionally held by conventional healthcare providers (Cioni & Lovari, 2014). To this end, data analysis is used to better understand the populations' health challenges based on factors such as geography, age, ethnicity, gender, socio-economic background etc. as well as for the purposes of public health surveillance (Brownstein, Freifeld, & Madoff, 2009; Cooper et al., 2001; Mackenbach et al., 2015). While few would dispute that Big Data holds much potential to deliver radically improved health outcomes at more cost-efficient levels, the digital health development has not yet reached its full realisation and still faces many challenges (Cummins & Schuller, 2020).

While Big Data is formidable in its own right and has the capacity to alter the way future public healthcare is managed, population data have drawbacks that restrict the usability of this information. For instance, the collection of wellness data is seldom done in real-time, meaning that whatever conclusions one may infer from this information are strictly based on past events. This means that this data is not usable for intervention, at least not on an individual level, since it is not possible to prevent that which has already occurred and predictive capabilities are restricted to assessing the probability on a group level, not on an individual level (Wänn, 2020). For that reason, conclusions inferred on a subpopulation are contingent on the stratification used and will not necessarily predict the health of any individual user. To the individual user, stratifications of the health of populations will only appear as abstract statistics that say little or nothing about oneself. For that reason, any investments and/or efforts made into improving the health of any specific subpopulation will risk becoming a wasted endeavour.

In order to safeguard relevance to the average denizen, Big Data needs to become customisable to the individual user. This would require further development of the extant analytical capabilities of data analysis, such as making more advanced use of AI, and increasing the number of data sources that are currently used for data analysis so that it also accounts for factors such as consumer behaviour, etc. This would involve individuals allowing their own health data to be accessed by Big Data companies providing health data analytics for the benefit of themselves as well as for that of a much larger population. Most healthcare providers do not generally possess a pool of data that has integrated all of a patient's information such as medical records, monitored data, diagnostic images, physician's notes etc. (Quelch & Rodriguez, 2016). However, by pooling data, it would be possible to develop a digital platform or a smart phone app. This platform would then employ the use of AI in order to look for data patterns in larger populations of people in a way that it will not be hampered by national borders or regulations since the users would have already provided their informed consent to the pooling of data (Wänn, 2020). This would allow for the identification of specific patterns that is known to exist in larger populations and match them with the conditions for the specific user with a high degree of probability, such as the risk of suffering a heart attack in the near future based on a comparative analysis with the user's work intensity, sleeping pattern, eating habits, blood values etc. Should the given prerequisites for a particular health condition be met and deemed to be impending, the app could provide the user with automated medical advice, possibly even setting up an appointment for a medical check-up and as such acting in a manner that provides for a suitable intervention. During the COVID-19 pandemic, there were several endeavours to utilise AI, and more specifically, machine learning, to tackle the crisis, but with limited success, mainly due to immature frameworks, models and modes of collaboration and data sharing (Bullock, Luccioni, Pham, Lam, & Luengo-Oroz, 2020).

By focussing on the single user and utilising data that is intrinsic and exclusive to that individual, it is possible to perform estimations of probable health conditions to a considerably higher degree of certainty and with greater precision. By using AI data analysis on population data, one can identify previously unknown patterns that can be used to anticipate sicknesses and diseases on an individual level. The diagnostics employed would be customised to the individual as it would be based on their personal data. Another aspect in this is that such data also acts as a deterrent towards unhealthy living, since data on customised personal health acts as a greater incentive towards changing one's own behavioural pattern, thereby helping to reduce the risk of certain illnesses even further (Celis-Morales et al., 2016). A Japanese study found that suicide rates initially seemed to decrease by 20% during the early stages of the COVID-19 pandemic (February to June 2020), only to increase by some 7.7% a few months into the pandemic (July to October 2020) due to psychological harm, e.g. financial strain or social isolation-related depression etc. (John, Pirkis, Gunnell, Appleby, & Morrissey, 2020; Tanaka & Okamoto, 2021). Future AI-based predictive tools could in this instance pick up on those users who are exhibiting suicidal patterns of behaviour and help alert the next of kin so that appropriate help can be administered in time.

However, it should be reiterated that in order for such a digital platform to function, there must be vast accessibility to patient data, and the individual consent of data must encompass wide areas of personal information. Nevertheless, the advantage for smart cities is that the extensive availability of smart devices will make it easier to track individuals and there is a greater availability of relevant data (assuming it is shared with the digital health platform) that can offer better customisability and relevance to the individuals living in that city. For instance, "deep learning" devices (a subset of AI which assumes a group of computational operations with the capacity to imitate the brain), seek to adopt a "learning process" that is based on the user's experiences (Jokanović, 2021).

Already now, there have been considerable advances towards various wellness solutions, including wearables and genomics analysis, but the problem is that these are all currently being developed within their own data silos (Wänn, 2020). In order for individualised and predictive healthcare with the possibility of intervention to become reality, there will need to be multiple data sources harvested and combined across large populations, which include medical history, genomics, behavioural data and real-time data from medical devices (Flores, Glusman, Brogaard, Price, & Hood, 2013). Examples of such technologies are *EnsoSleep*, a sleep scoring and analysis solution aimed at diagnosing sleep disorders, and *Advanced Intelligent Clear-IQ Engine*, a deep learning tool aimed to assist computed tomography scans (Benjamens, Dhunnoo, & Meskó, 2020).

As of today, as much as 80–90% of all available medical data is estimated to consist of unstructured text, which includes doctor's notes or patient e-mails (Garvin & Kimbleton, 2021). Hence, there will need to be AI tools that are capable to extract meaning from natural language to make sense of unstructured text (Garvin & Kimbleton, 2021; Hema & Devi, 2021). The present lack of usable healthcare data is currently presenting a key obstacle to creating a digital healthcare data platform. Also, extant data protection regulations are designed to safeguard privacy of individuals, but the flipside is that valuable healthcare data is generally only available within the domains of healthcare providers, i.e. hospitals/clinics and/or in single cities/counties/regions. Healthcare data from traditional sources, e.g. electronic health records (EMRs), in addition to alternative sources, e.g. medical devices, were approximated to grow from 153 exabytes (= 153 billion gigabytes) globally in 2013 and was projected to grow to 2,314 exabytes in 2020, effectively doubling the amount of data for each year (Miller, 2018). Data scientists anticipate that roughly 25 petabytes (= 25 million gigabytes) of genomic data will be produced annually worldwide by 2030 (Banks, 2020; Navarro et al., 2019).

Beyond this, personalisation of health data is a multibillion dollar industry. For instance, the global healthcare data storage market is expected to amount to US$8.11 billion by 2026 (Burns, 2021). The market for wearables is projected to grow by 20% annually, reaching more than US$161 billion (€150 billion) by 2028 (Ometov et al., 2021).

Early testing has shown favourable results so far. A 2018 machine learning analysis conducted by Google of 216,221 EMRs for adult patients hospitalised for at least a day, was effective at predicting in-hospitality mortality, 30-day unplanned readmissions and all final diagnoses (Banks, 2020; Rajkomar et al., 2018). However, in many other respects, the available analytics are marred with various shortcomings. Most particularly, this is associated with the fact that the datasets are often too small to train the AI for other purposes than general administrative automation and simpler predictive powers e.g. assessing matters such as how long a patient is expected to stay in hospital or the risk of readmission in next 30 days (Wänn, 2020).

EMRs contain data to answers the "what" in healthcare. Healthcare data provide rich and detailed background of diagnostic data such as radiological imaging, laboratory tests, pathology tests and clinical observations etc. (Davis, 2020). Likewise, these records contain information on the outcomes, such as what malady the patient was diagnosed with, what treatment they received, and the result of said treatment. The data is in and of itself ample to initialise the preparations of teaching an AI to identify patterns on clinically produced data alone. However, this possibility is cut short by the fact that EMR data are siloed by proprietary data models with low interoperability. Unfortunately, healthcare providers are largely unable to exchange anything beyond mere rudimentary patient information across organisational boundaries. An AI-driven predictive digital healthcare platform would require large amounts of data records in order to serve a purpose, and often in much greater quantities than what is found within a single city, or even a region. For cities with small population sizes, this would entail that there is a need to gather data at a national level. Thus, a government agency would need to be appointed with the purview of developing a national EMR platform. However, establishing such an agency is generally difficult, at least historically in the western world, since the participation rate by city or county/region tends to be low, and the extant cases available for use are not always clear. Attempting to widen the scope would require new laws in the area of healthcare privacy, which is in itself often a Herculean task. Another option would be to change the ownership of and access to healthcare data to the patient via a personal health record (PHR). This is a health record where health data and other information related to the care of a patient are maintained by the patient (Tang, Ash, Bates, Overhage, & Sands, 2006).

A PHR stands in contrast to the EMR inasmuch that the latter is operated by institutions, e.g. hospitals, and contains data entered by clinicians, e.g. billing data, to support insurance claims. A PHR serves to provide a complete and accurate summary of an individual's medical history that is accessible to them online. The health data on a PHR can include information such as patient-reported outcome data, lab results and data from devices, e.g. wireless electronic weighing scales (Archer, Fevrier-Thomas, Lokker, McKibbon, & Straus, 2011).

With a PHR, patients can allow direct access to their healthcare data to any actor they see fit. This would provide for swift and seamless work-around solution to the issue of data privacy, since with PHR, the patient possesses control of their own data, effectively bypassing patient data laws. Already now, there have been motions towards initialising such a development. For instance, in January 2018, Apple launched a collaboration with 12 hospitals in the US (Dhru, 2018). Apple offers a health app service called *Health Records*, in which patients can download, synchronise and access their medical records data in a PHR via a health app on their smart phones (Kotler, Stevens, & Shalowitz, 2021). Using a PHR, individuals may grant access to their data to a third party, e.g. Apple, enabling access to medical data that were up until this point legally inaccessible. The creation of this service was made possible due to Apple's 2016 acquisition of Gliimpse, a company that specialised in developing PHR software with the ability to scrub medical records for medical data, and thereby populating a PHR with accurate and useful data (Wänn, 2020). Making healthcare data interoperable is an essential step. Unless there is interoperability, it will not be possible to collate a person's medical data from multiple EMR sources. Also, it would not be possible to compare data between individual with data from other sources. Naturally, integrity and patient confidentiality will need to be addressed in a satisfactory manner (Sonn, Kang, & Choi, 2020). One frequently debated solution concerns the implementation of systems such as blockchain technology (Qiu, Liang, Shetty, & Bowden, 2018). Studies have shown that it is indeed possible to exchange PHR data in a private blockchain network (Park et al., 2019; Roehrs et al., 2019). Notwithstanding, a blockchain-based PHR platform that can be used in practice will require many improvements, such as reducing the data size, improving personal information protection, and reducing operating costs (Park et al., 2019).

5 Conclusion

The aim of this chapter was to explore how smart city technology is transforming the nature of welfare and healthcare with new, innovative applications of technology, and how this may develop following a pandemic such as COVID-19.

Action 1: Consider a Wider Application of Personal Health Records (PHR)

This chapter has explored the philosophical understandings of health and determined that digital technology has shifted the notion of health as something that should only be treated when there is something wrong, to taking more pre-emptive care to stop illnesses from occurring to as great extent as possible. In this way, one popularly speaks of "wellness" as well as "healthcare" to a much greater extent in this day and age. However, the modality of the current healthcare system lacks preparedness for future pandemics and/or other comparable large-scale societal disruptions. Personalised healthcare holds unprecedented potential in terms of advancing preventive and intervention care. This could ultimately save millions of tax payer dollars while saving the healthcare service considerable resources in the decades to come and create a better sense of preparedness ahead of future pandemics. In this, a wider application of PHRs would help facilitate a more widespread and unimpeded use of personalised healthcare/wellness.

Action 2: Deploy Advanced Community Health Intelligence

Historically, pandemics have plagued cities throughout the ages. So, how is it that there is a crisis each time a pandemic strikes and why is there not a better sense of preparedness, especially given the fact that there have been multiple occurrences of pandemics/pandemic-like situations even in the era of digital technology? One explanation for the lack of lessons learned following previous pandemic public health crises is the insistence of the continuing and exclusive adherence to the traditional model of public health emergencies as opposed to relying on preventive community health protection and promotion practices. While authoritarian implementation of public health emergencies will continue to play an important role at certain given times during future pandemics, it is more likely that the efforts will become more effective if they are preceded, combined and trailed by a more advanced level of community health intelligence such as that enabled by health data tracking in smart cities.

Concluding Remarks

Three quintessential steps that must be taken in order to resolve the issue of future healthcare are to: (1) set the patient data free, (2) make this data interoperable, and (3) make adaptations to systems such as e.g. the blockchain technology to allow for it to be more compatible with PHRs in regard to technical optimisation and patient confidentiality. Without these reforms, there cannot be a meaningful analysis of healthcare data that benefits the denizens of tomorrow. In terms of improving the welfare, it is essential to take measures towards improving the air quality in megacities and thus providing a safe environment for the denizens. It is possible that air purifiers, both the indoor as well as the large-scale outdoor variety, can play important roles in the future in combating pandemics such as COVID-19 and polluted air, in general along with its associated health risks.

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7 Global Hubs

Setting Up and Sustaining International Businesses in Smart Cities in Times of Pandemics

1 Introduction

The notion of a "hub" is not easily defined even though it is often tacitly understood in the common business vernacular. A "hub" can best be described as a place, or a building, in which goods/services, messages and/or ideas are exchanged with an outstanding record of originality (R. T. Rosen, Rosen, Digh, Phillips, & Singer, 2000). They often belong to, or are initialised and/or supported by organisations, corporations, governments or assemblies, etc. To this extent, business hubs are developing internationally to ensure that entrepreneurs, business owners, and self-employed people have an attainable option of creating, developing and maintaining sustainable means of business. Essentially, a "hub" is there to support all elements of an innovation ecosystem in facilitating a business enterprise at a given location (Heisterberg & Verma, 2014; Sharma & Meyer, 2019).

What then makes a global hub develop? In simple terms, it is a combination of both natural and human resources, causing what in macroeconomic terms is known as a *multiplier effect*. This, in turn, can be oversimplified in the following manner: assume variable x changes by 1 unit, which causes another variable, y, to change by 5 units. In this case, the multiplier would thus be 5. If x increases by 2, the multiplier is 10, and so on. In this way, multipliers can be calculated to analyse the effects of policy (monetary and fiscal) on aggregate output (Dymond, 2015; Rademaekers et al., 2012). In the case of global hubs, the human resources are a multiple of the natural resources, meaning that the better the natural preconditions are for setting up a particular type of global hub in an area, the more vibrancy in terms of human resources the hub would attract. Example of possible natural resources can be factors such as the following (Amadeo, 2022; Boudreau, McDaniel, Sprout, & Turgeon, 2012; Rademaekers et al., 2012):

- Strategic location that can encourage/attract investments to a particular region/location.
- Coastlines that can facilitate trade.
- Physical factors aiding the growth industries, such as the existence of minerals, ore, oil, gas, forest etc.

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In short, anything that would improve the preconditions of physically setting up a hub in a given location. Additionally, there are also human resources, which may include examples such as the following (International Labour Organization, 2011; Knell, 1993; Michie & Sheehan, 2005):

- Sizeable and available labour force.
- Skilled labour (facilitated by the availability of colleges and/or universities).
- Widespread proficiency in major international languages (predominately English, but also French, Spanish, German, Russian, Chinese etc.).

The acceleration of technology has had significant impact on hub development inasmuch that it has widened the focus on innovation, open systems and the upgrading of extant hubs. In particular, the ecology of hubs is shaped by the globalisation of production and the future potential of smart cities (Oqubay, 2020). This development has facilitated the growth of "global hubs", which can best be described as a city or region that provides a focal point for aforementioned activities that carry global influence. In a way, smart cities in and of themselves can be argued to be a form of "global hub" inasmuch that they are able to provide means for innovation that is not restricted to the actual physical location of the city, but can be carried out using the city's resources regardless (Awad, Hyder, & Irfan, 2017; Barlow & Levy-Bencheton, 2019). However, this is not necessarily true, since the existence of a smart city does not by default entail an influx of new denizens, businesses and investments (Angelidou & Mora, 2019; Cugurullo, 2013; Datta, 2015; Komninos, 2015). The aim of this chapter seeks to discuss how smart cities can use digital technology as a facilitator for global hub businesses in times of a pandemic, or a comparable disruption, and the steps needed to succeed.

2 History of Global Hubs

Spanish sociologist Manuel Castells (1989) argued that the quality of large cities is not defined by their size per se, but rather, in the way they serve as nodes to the global economy. In this manner, global hubs are integral components as they effectively serve as these nodes to companies while cities, in turn, serve as nodes to the global economy. It is difficult to establish an exact point of origin for the "global hubs", but it is argued that the Great Exhibition, held in Hyde Park, London, from May, 1 to October, 15, 1851, might have been something of a starting point inasmuch that it was an event that brought all corners of the world visible in one place (Drew, 1852; Syrjämaa, 2020). More precisely, it was held in the glass-and-iron Crystal Palace (destroyed by fire on November 30, 1936) that was erected especially for this occasion and featured prominent attendees such as Charles Darwin, Karl Marx, Samuel Colt, Charlotte Brontë, Charles Dickens, Lewis Carroll, George Eliot, Alfred Tennyson, William Makepeace Thackeray, along with several members of the

Orléanist Royal Family and Michael Faraday, who assisted with the planning and judging of exhibits (Auerbach, 1999; Castleden, 2009; Piggott, 2004). The Great Exhibition in London, as well as subsequent fairs in cities, such as Paris, Vienna and Chicago, were temporary hubs on a grand scale, often described as "condensed representations of the world" (Syrjämaa, 2020, p. 381). The exhibition in the Crystal Palace drew crowds of about 6 million people, whereas the subsequent exhibitions would draw manifold more attendees, with the one in Paris attracting more than 50 million visits in 1900 (Piggott, 2004; Syrjämaa, 2020). However, it should be noted that this number denotes the number of visits and not attendees, since it was common for some people to visit the fair more than once and the scorekeepers did not track the unique number of attendees (Syrjämaa, 2020). The purpose of the exhibition was to display, assess and accelerate the progress and development in various fields such as science, technology, industry, art, culture and morals. Although the exhibition was chiefly aimed at contemporary state-of-the-art achievements, there were also some instances featuring retrospective exhibits, as well as some exhibits of projected visions of the future. The overall aim of the exhibition, and the ones following it, was to spread knowledge and facilitate an exchange of ideas.

3 Global Hubs Today

Since the Great Exhibition, the concept and implementation of "global hubs" have been refined and expanded upon. Today, hubs serve as a means of providing organisations as well as denizens with additional business opportunities in new cities, than to merely exhibit the latest pièce de résistance in innovation (although this aspect indubitably still lives on as well).

In no doubt, the global cities of today have been given a more prominent role in the global economy inasmuch that economic growth is more often than not centred on urbanised regions and cities. As mentioned in *Chapter 1: Introduction*, roughly 55% of the world's population, or 4.2 billion people, live

Image 7.1 The Crystal Palace in London, during the Great Exhibition of 1852.
Source: Dickinson Brothers, Public domain, Wikimedia Commons.

in cities, and it is expected that the migration to cities will continue over the years to come, with approximately 68–70% of the world's population expected to live in cities by the year 2050 (United Nations, 2018; World Bank, 2020). This also entails that more than 80% of global GDP is generated in cities, meaning that continued urbanisation can contribute to sustainable growth if managed well by increasing productivity, allowing innovation and new ideas to emerge (World Bank, 2020).

Promulgated by reduced transportation costs, advanced technologies, liberalised trade agreements and an overall more open market, globalisation and foreign direct investment (FDI) serves to connect cities and organisations (Wall & van der Knaap, 2012). Oversimplified, FDI entails an investment by means of controlling ownership in a business in one country by an entity based in another country. A "direct investment" in this context signifies when a company makes a physical investment and purchases things as buildings, factories, machines and/or other itineraries outside of their home country. In contrast, "indirect investment" is when a company (or a financial institution) purchases positions or stakes in other companies on a foreign stock exchange (Tulsian & Tulsian, 2019). In this way, FDIs and the rise of global hubs are strongly interconnected (Ghoshal & Ghosh, 2017; OECD, 2012). That is to say, global hubs are in many cases a result of FDIs, as it allows a company to exert control of their enterprises set up in other cities around the world. It also means that big cities will continue to play crucial roles to the world economy. For instance, in 2016, 40% of all Swedish export companies were headquartered in the capital, Stockholm (Stockholm Chamber of Commerce, 2016). In comparison, 32 Swedish companies were listed in the 2022 edition of Forbes Global 2000 list of the world's largest public companies, of which 26 (i.e. more than 80%) were based in Stockholm (Murphy & Contreras, 2022).

The aforementioned example highlights the importance cities play in not only for the sake of the national economy, but also for the economy at large on a global scale. In order for a city, or a city region, to stand out among the competition from other cities, it is necessary to possess a sufficient amount of foresight, outreach and innovativeness along with the ability to harvest knowledge and insights from the outside world (Bathelt, Malmberg, & Maskell, 2004). The digital transformation of modern day society and enterprises has facilitated innovation and productivity tremendously. In order to help cities flourish further and make themselves internationally renowned, it is necessary for companies and organisations continue to expand beyond the domains of its native city. In scaling up its operations by establishing "hubs" in other cities, cities are able to spread their imprint.

Conversely, by opening up to other cities' hubs, the city may attract foreign investment and an increased influx of high skilled labour as well as serve as a catalyst to other, similar businesses in the area (Beaverstock, 2012; Friedmann, 1986). For instance, the Japanese Kyoto-based video game company Nintendo formed a US subsidiary in 1980, Nintendo of America, originally located in Manhattan, New York. However, the location was later moved to the city of Redmond, Washington (located a little over 15 minutes outside of Seattle) in 1985, with the Seattle harbour being the US's closest to Japan at only nine days by boat, along with a lumber production market for the arcade cabinets (often made with wood side panels) that were in demand at the time (Ryan, 2011; Seale, 2011; Sheff, 1993). The following year, 1986, Microsoft moved to the same location as well, having previously been located in the neighbouring city of Bellevue since 1979 (Knight, 2014; Richardson, 2004).

In spite of Redmond's relatively small size, an estimated population of 72,507 in 2020, the city has since then been internationally renowned for being home to both Microsoft and Nintendo of America's headquarters, along with numerous other companies, many of which are active in the high-tech industry (United States Census Bureau, 2021; Zerdick et al., 2000). In 2015, SpaceX and Hyperloop Genesis announced the opening of a facility in Redmond, with an expressed focus on research and development (R&D) and manufacturing for a proposed Internet communications satellite constellation and new transport systems (Boyle, 2017; De Selding, 2015; Wingfield, 2019). Undoubtedly, a major part of Redmond's traction lies in the fact that it, unlike many neighbouring cities in the area, is bereft of business and occupation tax on income, although it does enforce a business license fee per employee (Day, 2017). As of 2022, this annual license fee was set at US$122 per full-time equivalent employee, corresponding to 1,920 hours worked in Redmond (City of Redmond, 2022).

4 Branding

4.1 Global Hubs as a Brand Name

Essentially, global hubs exist as a means for global firms to reach out and establish a presence in other cities. One may also argue that certain cities have become so powerful that they are in many ways thought of as being similar to city-states, such as Singapore, Hong Kong or Dubai, with several other cities, like London and New York etc. also displaying similar tendencies (Clark, Schultz, & Taylor, 1997; Thrift, 1999). In many ways, these cities function as brands in themselves. Other times, a company or firm may serve to accentuate the connection to a specific brand, and the hub they establish in foreign cities may, by extension, serve as unofficial "emissaries" for the home city.

In this way, establishing global hubs is about much more than merely fostering business growth and creating new job opportunities. Establishing global hubs is thus also a means of interconnecting cities and creating a cultural and emotional connection to another city and spread a sense of shared culture, or identity, through the enterprise that is sets up in the area. Essentially, it has the potential of establishing a city as a "brand name" and build up a form of "storytelling" around the city and the message it purports to represent. In that way, the global hubs serve to generate attractiveness also for businesses and enterprises on a larger scale. Effectively, the type of branding carried through a global hub would place itself somewhere between commercial branding and place branding, inasmuch that it focusses both on trade branding (like commercial branding) and creating significance by linking image with a sense of identity (like place branding) (Kaefer, 2021).

In South Korea, the Seoul Metropolitan Government has, since September 20, 2012, operated the "Shared City Seoul" initiative in which companies and organisations are selected as a means of promoting and sharing knowledge and events about Seoul and its current activities (Jo, 2021; Seoul Metropolitan Government, 2022b). This is referred to as the "sharing hub" and is operated jointly by a project team and the city authorities. The expressed intent for the companies participating in the sharing hub is for them to support the shared use of public and private resources while boosting civic engagement and supporting local business simultaneously (Seoul Metropolitan Government, 2022b). The participating companies gain much valuable revenue in the form of intangible assets, such as promotion and experience (Jo, 2021). By being selected to the "Sharing City Seoul" list, the city government is publically acknowledging that the company or organisation is one that "make[s] Seoul a sharing city" (Seoul Metropolitan Government, 2022a, para. 1). This is one example of how a city can organise a hub under which several companies operate, but more commonly hubs exist as an extension of a firm itself.

By setting up global hubs, companies communicates that they are not merely serving customers in their own local city, nor even in their own country, but rather on an international level. In some cases, some companies are intrinsically intertwined with a specific city or town, wherein there is often an associated "story", commonly known as "myths" that describes the company's history and values in a way to which people can relate. These are often referred to as "company towns" or "company cities", of which one example is the American multinational manufacturing company Kohler Co., headquartered in its namesake village, Kohler, Wisconsin. The conveyed "myth" is one in which the company CEO, industrialist (and later Governor of Wisconsin) Walter J. Kohler, Sr. in 1916 began to develop a "garden industrial village" adjacent to his factory in Sheboygan County, Wisconsin in an attempt to stop the neighbourhood from turning into a fetid industrial district, thus turning the village into what it came to be (Alanen & Peltin, 1978; Oberdeck, 2005). In a similar way, the products sold by Kohler Co., through various hubs across the world, relate largely to home improvement fixtures heralding the aspirations of Walter J. Kohler, Sr. to improve by building.

In this way, the "myth building" around a company plays an essential part. The myth building is particularly true when it comes to creating a national, or regional, mind-set that is to be associated with the brand. At bedrock, the creation of a national/regional ideology is about getting the denizens to identify with how a specific nation behaves and what values it represents, even if so in a stereotypical fashion. On this note, it is important to clarify that the word "stereotype" is ever so often misinterpreted and is often used to describe caricature-like depictions that carry particularly negative/derogative connotations. However, in this context, this is not necessarily so. This is a point that is heavily emphasised in Gesteland's (2005) research, namely that "stereotypes" are, in fact, important in building myths because they help us understand cultures from a simplified perspective that allows for better comparisons.

4.2 The Power of Adaptation

It is important to remember that consumer goods, such as clothing, food etc. often take on product adaptation depending on where they are sold. For instance, in India, Coca-Cola has traditionally been marketed towards the urban young with a marketing that speaks their idiom. The reason for this is that cola drinks in India have traditionally appealed to a small market segment of metropolitan India (Gesteland, 2005).

The plethora of market segments around the world are by no means homogeneous and are indeed found in many different places, among many different people in many different countries and cultures. In order to cater to these, it is natural for the strategy to be diverse and dissimilar. Nonetheless, this is not to say that the brand has to lose sight of its national heritage. For instance, the wristwatch manufacturer Swatch would often tout its Swiss heritage across its retailers (hubs) across the world, and even incorporated the Swiss flag into its brand logotype (Shi, 2015). This was much in thanks to Switzerland's longstanding recognition as a watch-making nation. Likewise, the German car brand Volkswagen used a German-language slogan ("*Volkswagen. Das Auto*") (Fatma & Rihab, 2019). Notwithstanding, few companies are as overly explicit as Swatch, as Holt (2004) teaches us that national ideologies are (almost) always expressed implicitly and by proxy. This is often conveyed in the form of the aforementioned "stereotypes" by illustrating imagery that is often associated with a particular country, region or even city. By leaning on stereotypes, the organisation/company conveys a story that builds and solidifies the message it wants to communicate to its consumers and why it is a preferable option as opposed to a different company that lacks these qualities.

4.3 Tapping into the Myth

Choosing to execute different myths in different markets is walking a tightrope, since it is challenging to succeed and at the same time, it is potentially hazardous for the brand itself. It is difficult because several myths need to be shaped, one for each region, and implemented convincingly. This alternative would be very costly in terms of effort and marketing. Worse still is the potential harm that it can cause the brand.

In order for a brand to become iconic, it needs to show a high level of authenticity. This, in turn, consists of two different parts, namely "literacy" (*being* true to the myth) and "fidelity" (*staying* true to the myth) (Holt, 2004, p. 65). Performing different myths for different markets would make the brand fail on both points. However, if performed well enough, conveying an identity myth will provide the customer with an emotional attachment as well, and the brand will then have acquired a "personality" or a characteristic trait to which it may be associated (Holt, 2004; Wang, Butt, & Wei, 2011). A notable example is Singapore Airlines (SIA), which was ranked #32 on the 2022 edition of Fortune magazine's top 500 list of the most admired companies in the world (and ranked at #18 in 2019, prior to the COVID-19 pandemic) (Fortune, 2022). SIA has built much of its brand name capitalising on many of the popular Singaporean "stereotypes". In popular culture, SIA's imagery is undoubtedly most commonly associated with its long-serving, almost iconic "Singapore Girl", but beyond that, SIA has also established its brand in being a "trendsetter" and "industry challenger" (Chong, 2007; Daniel, 2000; Roll, 2015). Much of this is, in part, due to its receptiveness towards new technology. For instance, in February 2013, SIA was the first airline in the world to introduce 3D games on its entertainment system, KrisWorld. In 2017, SIA launched the "Suites" cabin class, the first in the world product which promised a "personal oasis" within a private space, exclusively on board its Airbus A380 fleet (Roll, 2021, para. 22). To this day, SIA maintains one of the youngest fleets of aircraft amongst all major air carriers, all the while keeping a stringent policy of replacing older aircrafts for newer and more fuel-efficient models (Vasigh & Rowe, 2020). Roll (2021, para. 18) argues that SIA "have always been first in line to take delivery of new aircraft types like Boeing 747 jumbo jets, Boeing 777, and they were the first airline to fly the Airbus Super jumbo A380 in 2007".

SIA also holds the distinction of operating the longest non-stop passenger flight in the world by flying from its hub in Singapore to Newark International Airport, New York, a 16,700 km, 19-hour flight (Singapore Airlines, 2021). In October 2018, SIA opened this route by introducing the airline's new fuel-efficient aircraft, the Airbus A350–900ULR (ultra-long-range) (Baxter & Srisaeng, 2018). SIA made a point to schedule its departure from Singapore before midnight in order to arrive in New York early the next morning, to allow for business travellers to be well-rested for a full day of work, thereby conveying a sense of customer centricity in its brand beyond being at the technological forefront (Roll, 2021; E. Rosen, 2018; Singapore Airlines, 2021). SIA would break its own record in 2020 by extending its travel distance by 4.8 km with its non-stop service from Singapore to New York-JFK International Airport (E. Rosen, 2020).

The national/regional identity is particularly explicit in the fashion industry, where many brands are associated with their country of origin. Examples of this include Burberry (England), Yves Saint Laurent (France), Gucci (Italy) and Ray-Ban (USA). Each of these brands has company offices (hubs) spread across the world. However, perceived national brand identity is not necessarily synonymous with actual geographic spatiality. For instance, even though Yves Saint Laurent and Ray-Ban are, as of 1999, owned by Italian companies (Gucci and Luxottica, respectively), the national heritage of the brands still remain unchanged. These brands have their own iconic fashion items, such as the Burberry's Trench Coat, Yves Saint Laurents' brown and beige bags and luggage, Gucci's oversized black plastic sunglasses and Ray-Ban's aviator sunglasses. All of these fashion items have managed to become global icons because they tell stories that tap into myths that are important to people across many different cultures.

It is possible to see a certain pattern when looking at these examples of global fashion and brands. The trench coat became famous during the trench wars of World War I. Ray-Ban's aviator model became famous during World War II; they were issued to the soldiers in the US army. The Volkswagen Beetle became famous during the flower power-age since it became a symbol for that very movement. Oversized black plastic sunglasses became an expression for European jet-setters, and other young people that wished to get a taste of that lifestyle.

It would seem that not only is the location important, but so is the time. Holt (2004) discusses how a brand can go from being iconic to regular and then back, all depending on how well its myth resonates with that of the national culture at the given time. Fashion knows how to deal with small changes in attitudes and preferences over very short periods of time. Some brands choose to be innovative and change markedly from season to season while others remain similar. It should be emphasised changes in fashion trends are not imperative for iconic brands as such. However, following changes in culture and adapting its myth treatment accordingly most certainly is.

In order to tap into a myth that is important and compelling in many countries, a company needs to find a myth that is of global importance at that point in time. Holt (2004) mentions cultural contradictions and raises an argument that, for example, American sentiments are not necessarily unique and inherent only to the US. That is to say, imagine an American worker experiencing his/her job being outsourced or automated, and the subsequent loss of identity this brings and how this sentiment is echoed by workers in so many other countries as well. These are historic shifts that people across the globe are connected to and can identify with. Bell (1970, para. 13) provides another, more overarching, example of the cultural contradiction:

> The characteristic style of an Industrial society is based on the principles of economics and economizing: on efficiency, least cost, maximization, optimization, and functional rationality. Yet it is at this point that it comes into sharpest conflict with the cultural trends of the day. The one emphasizes functional rationality, technocratic decision-making, and meritocratic re wards. The other, apocalyptic moods and antirational modes of behavior. It is this disjunction which is the historic crisis of Western society. This cultural contradiction, in the long run, is the deepest challenge to the society.

4.4 The Subconscious Nature of Brand Presence

Many organisation brands turn into culturally constructed symbols in the sense that the brand manages to make itself important and/or relevant to the individual and this is much in thanks to the added promotion brought by its global hubs (Bengtsson & Östberg, 2006). That is to say, the company brand essentially transitions from being merely a brand name to becoming part of popular culture, thus turning itself into an "invisible brand" to a large portion of its customers/consumers. In other words, it becomes a brand that enters the household environment and blends in amongst the surroundings in an inconspicuous manner. As such, the brand more or less becomes a part of the consumers' sub-consciousness. In a sense, it is easier for a brand to enter a household, if it does so in passing than if the customer actively has to seek it out and purchase its products intentionally. However, that is not to say that these organisations/companies act exclusively as "invisible brands", as they may have fostered different relationships with different people. That is to say, there are just as many people in different parts of the world who actively seek out a company through its hubs because they feel they have a certain affinity/bond with the brand. Alternatively, they may feel that the brand possesses certain quality values that its competitors do not. By the same token, it should be emphasised that although it may seem as paradoxical for a brand to be both "visible" and "invisible", it is nevertheless true as we have learned from previous research that the one does not necessarily cancel out the other, if it occurs in different contexts (Balmer, 2006).

Consequently, the major importance lies in the manner the global hub brand is communicated, as it invariably influences the way consumers ultimately perceive it. In other words, brands create meaning and by putting them in a cultural context that everyone can adhere to (to a greater or lesser extent), consumers will be able to feel a greater affinity towards the product and the brand as a whole (Bergvall, 2006). That is to say, that people from different cultures and in different cities around the world feel they can unite together around the brand the global hub represents in spite of the differences in their background.

The way in which companies may best benefit from their global hubs functioning as a cultural resource is to ensure that its brand name continues to stay in good standing with the customers. The way to do this is, of course, different depending on the brand and company. Still, it is important to remember that corporate brands are not manufactured in factories but rather in people's minds. As such, the perceptions of the brand lie within the consumers, divorced from the corporation's direct control. For example, a 2002 study showed that a majority of Coca-Cola's value (59%) could be directly attributed to its brand name (Balmer, 2006; Ray, 2010). Hence it is fair to say that the consumer's perception of the brand is the company's greatest asset and effectively, the corporate brand exudes a certain kind of trust and commitment (Gustafsson, 2005). That is to say, that the brand communicates that the company can be trusted to act as a long-term partner that will fulfil the consumers' needs. By acting as a cultural resource, companies will tend to become a natural, undisputed, part of consumers' preferences.

5 The Singaporean Case during the SARS Pandemic: How Pandemic Impact on Global Hubs

The most pressing way in which a global pandemic, such as COVID-19, is able to impact the establishment of global hubs, is by making it seem insurmountable for companies to establish new hubs in a new specific area. There is little doubt that global hubs are a signifier of globalisation, thus a salient question has been whether or not a global pandemic has the capacity to end globalisation as we know it (Aaltola, 2012). Indeed, it is a fact that due to the flow of people, goods and services, cities are vulnerable to pandemic threats, and the rapid spread that they have, can in no small part be attributed to the increasingly more globalised world. Specifically, viruses such as SARS, H1N1 (the "swine flu"), G5N1 (the "bird flu") and COVID-19 are all carried predominantly by humans and, in some cases, farm animals. Due to the global interconnectivity of e.g. the aviation, maritime and financial sectors etc. the spread of pandemics risk posing tremendous challenges to the global security landscape (Ad'ha Aljunied, 2020). Essentially, pandemics are not only lethal to humans and animals, but also to the status quo of the globalised city networks that are made up by global hubs.

In 2003, when SARS started spreading from Guangdong, China into its neighbouring cities and countries, such as Hong Kong, and later Singapore, it was merely a matter of weeks before the disease had gained a foothold in the entire geographic region (Zhong et al., 2003). In Singapore, 238 people were infected with SARS, of which 33 would ultimately die (Ooi, Lim, & Chew, 2005). Additionally, it cost the government roughly US$230 million to salvage tourism and transport industries such as retailers, restaurants and airlines (Curley & Thomas, 2004). The government's immediate response was to treat the pandemic in the same way as a terror scare, i.e. with preparedness and vigilance, and by conducting temperature checks at the airport on passengers arriving to Singapore via infrared scanning (Wilder-Smith, 2006). Checkpoints such as this, although necessary, did impact the flow moving between the cities, and thereby also on what makes cities like this "global". Due to the intensity of flow of people and connectivity of places, cities play a crucial role in the distribution of pandemics. As global cities are dynamic entities, they are connected via different forms of global "flows", including people, goods, services, people, transportation and information and communication (Ad'ha Aljunied, 2020). Professor Stefan Elbe, Director at the Centre for Global Health Policy at the University of Sussex, once wrote that "a newly emerging infectious disease outbreak can indeed only be a plane ride away" (Elbe, 2010, p. 39). For this reason, pandemics need to be regarded as borderless phenomena. One may, in fact, argue that the connectivity of global networks/hubs along with the flow of people, goods and services, actually facilitates the spread of viruses between countries and cities (Ad'ha Aljunied, 2020; Ali & Keil, 2008).

As the case of Singapore illustrated during the SARS pandemic, the service sectors that accounted for 65.7% of Singapore's gross domestic product (GDP) fell 3.9% by the second quarter of 2003 and job losses in the service sector climbed to as high as 47% throughout the SARS duration (Lee & Warner, 2008). Also, as a global city, Singapore's domestic market was most adversely affected when the denizens and visitors began avoiding public places that were known to be dense with people, resulting in places such as schools, shopping malls, markets, theatres and so forth, seeing their businesses plummeting. Consequently, the economy was mostly hurt by the loss in demand, fuelled by the high degree of uncertainly and fear that the pandemic brought on.

6 Establishing a Global Hub during a Pandemic

It is believed that global hubs sustain the most damage during the early stages of a pandemic spread (Ad'ha Aljunied, 2020). Still, the SARS episode, and subsequently the much more widespread COVID-19 virus, has shown that profound impact is to be expected on the economy following the onslaught of a pandemic. This also applies to the ability to set up new business ventures, and this has been particularly salient internationally in the case of COVID-19. This is due to the fact that COVID-19 was in its very nature different to the other, more known virus strands, and the fact that its geographic spread was so much wider than that of SARS.

This brings up the heart of the matter for this chapter. That is, in what way can digital technology be used as a facilitator for global hub businesses in times of a pandemic? Admittedly, pandemics and the insecurities they bring, make it explicitly difficult for companies to expand their business domestically, and even less so in successfully establishing new hubs abroad. By the same token, there is also a matter of dealing with the already existing hubs that a company may have allocated in different cities. In doing this, a number of various actions have been taken in different cities and countries around the world, such as imposing moratoriums on company dissolutions, and government-issued pandemic support measures, which have, to various extents, managed to inflate the number of surviving companies somewhat (Bounds & Tighe, 2020). However, establishing new global hubs in times of pandemics would therefore, explicably so, need to be done selectively and with utmost caution. It is true that in the UK there were 120,257 more registered companies at the end of September 2020 than there were at the end of June 2019 (Gov.uk, 2021). However, this is by and large the result of a "coerced" entrepreneurial endeavour brought on by a combination of lower interest rates, lower property costs and an abundance of people who have lost their jobs with few other options on the labour market than to start their own businesses (Bounds & Tighe, 2020).

As previously mentioned, the uncertainty factor also plays a hand, with the initial stages of a pandemic often being the most detrimental, when uncertainty is at its highest peak. However, it is nonetheless a risky endeavour and it is necessary for the business idea to be genuinely innovative and in demand in order to garner enough resilience to withstand the challenges brought forth by a society battling a pandemic. It is true that private investment remains a possibility for some enterprises. The lower interest rates have enticed some investors to consider new opportunities. For some new businesses, an alternative is to seek out a "business angel", i.e. an affluent individual who combines the pursuit of a profit with interest in the business (Brown, Rocha, & Cowling, 2020). Other than that, crowdfunding platforms are another possibility, as is peer-to-peer lending (Bounds & Tighe, 2020; Saksanian, Martínez-Fiestas, & Timana, 2020). However, the fact remains that launching a new business venture during a pandemic is a risky manoeuvre.

For global hubs, the stakes are in a sense even higher, because the business is also risking its brand name in the process. For that reason, there may be additional measures to consider should one wish to establish a global hub at that point in time. The digital transformation coupled with the COVID-19 pandemic has most certainly seen many enterprises take leaps and bounds into transitioning to online ventures. Setting up electronic platforms in new countries for online purchasing purposes would therefore seemingly not carry the same risks in terms of on-site staffing and procuring the necessary facilities (Papagiannidis, Harris, & Morton, 2020).

In setting up digitalised hubs, it is therefore essential to ensure that the digital infrastructure is resilient enough. In some cases, it could be advisable to reduce priority or possibly even suspend any non-critical infrastructure (Papagiannidis et al., 2020). Likewise, planned digital infrastructure work can be halted unless it is deemed that a project would directly contribute in addressing/alleviating the crisis at hand. In this way, resources are made available to support essential services that are essential to the company's survival. With most major companies in some way or another having undergone a digital transformation and an increasing number of enterprises continuing to make their way towards "the cloud", many hubs will be able to operate virtually in various nations and cities (Dwivedi et al., 2020; Papagiannidis et al., 2020). Naturally, this means that companies will most certainly need to spend more money and resources in securing reliable online services and scaling up their IT infrastructure. Global hubs will continue to remain an essential instrument for organisation to spread their presence to other places, while also acting as a facilitator that may help strengthen the bond between different cities and/or nations. Still, at the end of the day, setting up a global hub during a pandemic is something that needs to be considered on a case-by-case basis, and in that, a digital hub could be a good starting point, at least during the initial stages of the pandemic.

7 Conclusion

The aim of this chapter was to discuss how smart cities can use digital technology as a facilitator for global hub businesses in times of a pandemic, or a comparable disruption, and the steps needed to succeed. In establishing global hubs, it will be vital for companies to ensure that they take on the right strategic approach in promoting their brand name via the hub. Then, what are the steps that an actor seeking to set up a hub can take in order to consolidate its brand and presence on the new market?

Action 1: Address Cultural Contradictions in Society

In Holt's (2004, p. 214) words, "cultural activism centers on identifying and responding to emerging cultural contradictions and the myth markets that form around these contradictions". This means that the global hub would need to clarify what cultural contradiction it seeks to harmonise by establishing its presence and in doing so, it would serve to establish or build upon an identity myth that addresses these desires and anxieties. To clarify, cultural contradictions are indeed pertinent in this day and age, although the connections are not always clear. Hence, the global hub would do well to either (1) focus on one acute contradiction and to describe it in different scenarios, or (2) find a clear link that connects the different contradictions to each other.

Action 2: Build Myth Consistency

An important part about building the brand and advertisement is ensuring that the consumers experience and feel the same resonance from the brand, and that customers/consumers partake in similar "ritual actions". That is to say, the ability to "feel" and identify with a brand's message and viscerally experience the myth though one's actions in a way that one cannot do by merely experiencing select portions of a brand, such as seeing an ad in a magazine, or attending an occasional rally or a concert (Holt, 2004). This feeling is primarily conveyed through advertisement and the messages expressed therein. Nevertheless, the perceptions from advertisement alone are not necessarily shared, which leads to the next step.

Action 3: Create Brand Identification

Following *Action 2*, an adequate course of action would thus be to present the same consumer experience but in different ways and in different channels. In securing this, (1) brand loyalty is essential. Specifically, brand loyalty benefits the organisation/company not only through increased sales, but also through customers becoming less sensitive to the competitors' marketing activities, which ultimately makes it more difficult for the competitors to enter the market at all. In doing this, it is necessary to determine what the (2) customers value most about the company and the products/services it provides. Furthermore, one must then (3) seek out what each customer group value most about the brand's myth. In this way, the brand loyalty becomes a product of the relationships between these three groups.

The brand's customer groups can most easily be defined as either: "insiders", "followers" or "feeders" (Florea, 2015; Holt, 2004). The "insiders" are those whom the myth is about, i.e. the ultimate consumer segment that are all about "living the myth" the brand image wishes to convey. These people serve as the greatest sources of inspiration. The "followers" are those who deeply identify with the myth and to some extent wish to be like the "insiders", although not to the fullest extent. The "followers" attract the next group of customers, the "feeders". The segment often constitutes the vast majority of a brand's customers. However, they can, in a less flattering analogy, be compared to cultural parasites, as they only possess a superficial connection at best with the values promulgated by the myth, with no real loyalty to the brand and only consume the brand's services intermittently and interchangeably with other brands. Thus, this segment is rarely considered when determining the company's strategy and the brand image's direction.

For this reason, targeting the product is crucial. The brands that wish to establish themselves as an identity brand do not compete against other similar products, but against other brands with the same or similar myths. This is what makes it difficult to position the brand identity as the tensions in society that the brand should rebalance, is constantly changing. People today do not necessarily have the same aspirations they had, say, ten years ago.

Action 4: Identify Customer Groups

A global hub will need to identify the customer groups to enhance the insider's values and attitude in the communication and to understand the values and desires of each group. With its positioning, a company identifies the benefits and features that they want the company to bear. These are the benefits and features that they want the customers to keep in mind when he or she is thinking of the brand. The positioning statement can be viewed as the central part of the brand strategy. In other words, one can describe the positioning process as the brand clearly occupies a certain position in the consumer consciousness.

Action 5: Clear Communication of Core Values

The company setting up the hub will need to determine what it really wants the customers/consumers to think/feel when they encounter the brand. This part constitutes the heart of the strategy and as such, the core values will need to be as precise and concise as possible. It is important to remember that the brand equity is the economic value of the brand. This value is based on future cash flows that the company believes will occur from setting up the hub, and these, in turn, are based on the customer loyalty one endeavours to generate. The company's brand equity is either positively or negatively related to customer loyalty and is dependent on the customers' perception and reaction to the promotion of the organisational brand and the goods/services it promotes. The brand equity can also be viewed as the brand's total assets and liabilities; in other words, a sort of valuation of the company's brand.

Action 6: Gain Loyalty

By communicating its core values clearly, a hub is able to win loyalty among the public and thus obtain higher brand equity. According to Holt (2004), the "identity myth" needs to be set inside a "populist world". A "populist world" implies a story that conveys both buttress (i.e. affirmative myths) and challenge (i.e. myths of resistance) to the country or city's ideology, traditions, and/or customs. In this context, an "identity myth" grounded in a "populist world" will relay an image of people living in a particular kind of way because they desire to live that way, rather than being mandated to do so because of what someone else tells them to do. This is essentially the hub's function in uniting these people, along with their shared faith and desire. The company behind the hub represents a brand that wants to make people think differently about themselves and about their surroundings.

Brands that successfully accomplish a cultural placement in the popular culture acquire an aura of authenticity which consumers covet as they seek to create distinctive personal identities. In other words, people wish to share the values of the brand and feel that the brand is offering them a personal identity that is solving the perceived "contradiction". They want something that they feel is missing but at the same time is still compatible with their mind-set, and familiarity, i.e. "new, but relatable".

Another possibility given the onerous situation caused by pandemics that linger for an extended period of time (such as the case with COVID-19) is adopting a "co-branding strategy". This entails that the company wishing to set up a new hub would cooperate with another one wishing to do the same, in order to create a unique product/service that would still be familiar to the consumers of both companies' products. This can be achieved by, for example, conducting joint advertising campaigns and announcements. The purpose of entering such cooperation would, in part, serve to share the risks and expenses in setting up and running the hub, but also to strengthen the position of both organisations on the market by acting in synergy.

Action 7: Co-brand

Should the hub choose to enter collaboration with another hub, they should consider which companies they could cooperate with in their promotion campaigns in order to attract more customers and increase their brand awareness among the general public. In doing this, it is also essential that there is a positive exchange with the other collaborating party. Once alignment has been established, the hub could then be set up as a co-brand in order to further develop and expand upon a "myths" with which the customers/consumers are able to relate.

Concluding Remarks

Admittedly, setting up global hubs during pandemics are not the ideal circumstances. However, global hubs will continue to be essential to the development of enterprises and to the expansion of the business landscape. Global hubs also serve an important societal function inasmuch that they, in essence, aid to sharing and distribution of various types of knowledge and development. They serve to reduce the distance between different cities, regions and countries by acting as a "liaison" between actors and places.

So much of the prosperity and economic growth in our societies today are rooted in the foundation of free trade. In that, global hubs serve as a connector and a stabilising factor for the economic system. However, the uncertainty brought by pandemics tend to hit societies and systems exorbitantly hard, and impedes the otherwise stabilising position that global hubs would offer. Needless to say, this entails that global hubs will also need to adapt and conform to the ways they are set up in times of persistent, widespread pandemics. Existing global hubs will need to be supported through various relief funds set up by the government, particularly so if the goods they sell or the services they provide carry a considerably important function to society. As for setting up new global hubs, sharing risks with other actors, or utilising technology to establish the hubs digitally, at least initially, may be ways to balance the practical financial risks brought on by a pandemic (or comparable disruptions). Regardless, the single most important aspect the hubs themselves will need to continue doing, is to uphold their brand name and exude stability and reliability in a time when people in need of reassurance will look to those institutions that offer a sense of familiarity, unity and hope.

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Part III

Durability

8 Digitalisation

Optimising a Pandemic and Post-Pandemic Smart City

1 Introduction

The desire to communicate more effectively has, throughout history, been one of the major driving forces behind the development of new technology (Bard, Söderqvist, & Larsson, 2020). It is not possible to discern an exact moment in time when communication became a quintessential component of mankind's development, but the spoken language is believed to have developed less than 200,000 years ago (Berwick & Chomsky, 2016). It is through the ability of abstract thinking that we are able to conceive new technology, and this ability of abstract thought emanates from a linguistic system of symbols. As such, the development of language has made it possible for humans to evolve socially, and to gather and maintain collectives. This, in turn, opened the ability for humans to form interpersonal relationships between one another. Language is not only the key to developing social life, but it is also the key to developing the notion of innovative and creative thinking (X. Fan & Li, 2021). Language and communication stimulates creativity and intelligence, while also enabling the spread of knowledge and information.

Undoubtedly, the digitalised society of this day and age comprises the most comprehensive information revolution of all time. During the early days of artificial intelligence (AI) development, it was a popular conception that the end goal would be to devise an AI so advanced that would have the ability to act completely autonomously and in a manner so convincingly that it would pass a "Turing test" (Copeland, 2003). The "Turing test" can best be described as a "computer intelligence test, requiring that a human being should be unable to distinguish the machine from another human being by using the replies to questions posed to both" (Van der Zande, Teigland, Siri, & Teigland, 2020, p. 66). Proponents of this view would have said that a step towards securing this development was already demonstrated when IBM's chess-playing computer *Deep Blue* ultimately defeated the reigning World Chess Champion and grandmaster, Garry Kasparov, on May 11, 1997 (Goodman & Keene, 1997; Newborn, 2003).

Since then, technology has headed in a different direction. The emphasis is not placed on attempting to devise a computer system that can best

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Image 8.1 Garry Kasparov (left) playing chess with IBM's "Deep Blue" supercomputer during the second and final round in New York, May 1997. Israeli programmer Amir Ban (right) served as Deep Blue's "operator" and would physically make the move when prompted by the computer.

mankind, but rather on developing technology with the ability to enable and/or improve the communication between various networks. Digital technology is continuously improving, making it possible to perform calculations and estimations that were either time-consuming, or even impossible to perform in the days of yore. While digital technology requires an investment (sometimes in smaller and sometimes in larger amounts) in technical equipment, it only takes a few actions before it is capable of processing and conveying information once it is in place. Hence, the spread and accessibility of large quantities of data has nowadays become such a commonplace occurrence that it is a necessity in a modern society, and particularly so for modern smart cities. However, while digitalisation may help cities advance the spread of information and communication, there is a lingering question as to how this process is affected by a force majeure (such as a pandemic like COVID-19) that actually serves to restrict mobility in the cities as a means of reducing the spread of the disease (Franco, 2020; Vannoni, McKee, Semenza, Bonell, & Stuckler, 2020). To that end, the aim of this chapter is to explore how smart cities can leverage the benefits of digitalisation to relieve pressure on extant services and resources following a pandemic such as COVID-19.

2 Mankind's Approach to Digital Technology – A Philosophical View

Traditionally, there have always been two opposite views regarding the importance of technological advancement in society (Bard et al., 2020; Lindgren, 2017). The "sceptics" would argue that technological advancement is merely a matter of securing a cachet in being first with the latest innovations, and while that communicating this is intrinsic value in and of itself, it is the content of what is communicated that is of real importance (Bard & Söderqvist, 2002; Morozov, 2013).

The other view is the "ecstatic" view, which contends that digital technology serves as a panacea for most challenges in society (Bard et al., 2020; Lindgren, 2017). The proponents of this view contend that the freedom of information spread through digital technology will enable people to perform their citizenly duties in a more productive and meaningful way than ever before, effectively fostering the democratic system to reach its full potential (Bard & Söderqvist, 2002; Bard et al., 2020). The proponents also believe that social cohesion is found through digital networks and that other aspects of society, such as entertainment, will become more interactive as well, and thereby helping people to lead more fulfilling lives (Negroponte, 1995).

There, is, however, a third position, as proposed by Bard and Söderqvist (2002). This view dismisses both the "scepticism" and the "blind faith" in digital technology proffered by the aforementioned orientations. Rather, digitalisation should be viewed as a communication and information game changer to the preconditions relating to matters such as society, economy, culture etc. However, digital technology will not be able to change the fundamental differences between people's attitudes or even conflicts. Instead, it can be expected that these may develop into more intricate and impenetrable patterns and structures.

The introduction of new technology, like any new change, is not instantaneous. Changes take a certain amount of time to be devised and some more time to implement and yet some more time to be fully absorbed before functioning the way as intended. For instance, although there is scientific support that the printing press led to important economic change in the centuries after its introduction, it would take time, in some places hundreds of years, before it reached its full potential (Daly, 2021; Dittmar, 2011; Ensor, 2003). This was due to the fact that literacy was not yet sufficiently widespread in order for the printed word to impact the common man to any wider extent. Thus it would not be until after the Industrial Revolution of the eighteenth century and the development of the metal presses that utilised cylinders and steam power and enabled the production of 8,000 sheets of paper per hour (through what was known as the "lightning press") that society was ready to reap the full potential from this particular innovation (Harvey, 2017; Reece, 2012).

While the development of digital technology has been radically more rapid in its implementation, a sceptic would nonetheless readily point out that the

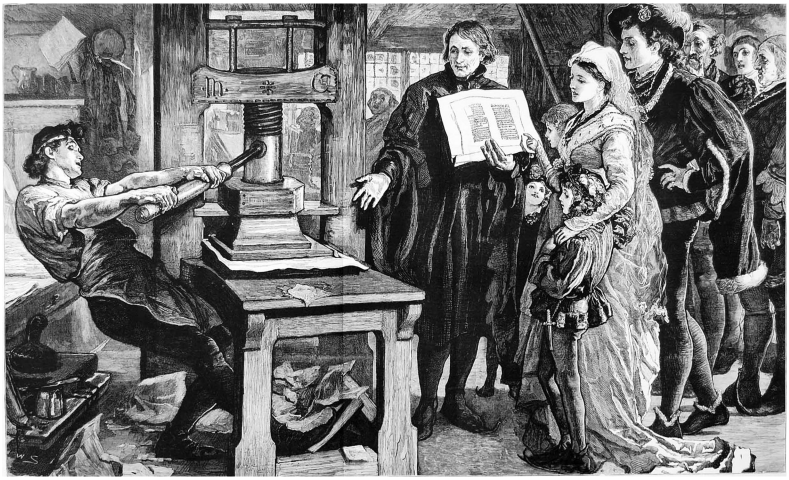

Image 8.2 William Caxton showing his printer to King Edward IV and the Queen in 1877.
Source: oldprint.com, Wikimedia Commons.

global economy is still very much linear and based on the production, use and disposal of various physical goods and services (Spellman, 2022). On this account, it is important to remember that the societal digitalisation, as far as it has reached at this point in time, is still in a nascent stage in many respects. That is to say, the digital transformation was never a question of completely replacing the production of physical goods and services, nor will it make physical products obsolete (Holzhauser & Schalla, 2017). Rather, it is about objects and concepts taking on new purposes and functions in a new, innovative manner, and promoting the use of various goods and services in a different way, with crossover functions to create new synergy effects. For instance, in the old days there would be a clear demarcation line between that which were "white goods" (i.e. large home appliance machines, such as washing machines, fridges, stoves) and that which were "brown goods" (i.e. consumer electronics used for entertainment, communications and recreation, such as computers, televisions, stereos, telephones). However, with the advent of Internet of Things (IoT), this line has become increasingly blurred, as white goods are now able to connect to the Internet as well as to other IoT devices via Bluetooth or other types of wireless technologies, in ways that many brown goods could do at a much earlier stage (Asadullah & Ullah, 2017; Das, Ganguly, Ghosh, Sarker, & Sengupta, 2016). Thus, today IoT compatible white goods are presented to a lesser extent exclusively on their ability to perform their primary function, but rather on their ability to make use of various "smart" function within the household, and possibly even on its ability to communicate with other "smart" devices in the home, such as one's smartphone etc. (Qayyum et al., 2015; Zhu, Lin, & Cheng, 2012).

The point of the matter is that the development of new digital technology is only a first step.

On this note, technology historian Melvin Kranzberg (1917–1995) once stated that "[t]echnology is neither good nor bad; nor is it neutral" (Kranzberg, 1986, p. 545). With this, he meant that technology impacts many different sociocultural areas and that this impact can stretch far beyond the area for which the technological device was originally designed. Likewise, the result of this technology may appear considerably dissimilar when introduced to a different context under a different circumstance. In more succinct terms, the mere existence of a specific technological innovation does not necessarily entail that there *is* an optimal or widespread application for it at the time of its invention, but that there *could be* in the future. The key is that there must be a variety of factors that coincide and conjoin at a given time in order to set a technological revolution in motion.

This is in line with the notions posited by French sociologist Jacques Ellul (1912–1994). His primary interest concerned the internal logic of technology and the radical impact it has on people's everyday life and on their environment. According to Ellul (1964), the primary and possibly even the most self-evident precondition for new technology is that the necessary apparatus must already be in place. This, in turn, assumes it has been preceded by a longer, ongoing historical process, given that each and every innovation is rooted in a previous era. What essentially differentiates an "innovation" from a "novelty" is that the former is the result of a series of various inventions of varying degrees that together form a powerful synergy that is stronger than the sum of their individual components. Ellul also contended that population growth plays a vital role in the propensity to develop new technology, since a population boom means there is an added strain on the available resources while there is an increase in demands that need to be satisfied. Moreover, Ellul also argued, somewhat paradoxically, that another condition for developing new technology is that the economic environment must be both stable but at the same time also undergo some form of dissolution or crisis. That is to say, there needs to be stability in the economy in order to undertake the necessary scientific experimentation which is likely initially unprofitable but nonetheless necessary. At the same time, there must also be a need for widespread and fast change brought on by an incentive to stimulate and absorb new inventions. Finally, Ellul argued that there must be a social climate in place that is accommodating for innovations, that is completely divorced from dogmatic taboos and/or the kind of social determinism that stipulates that behaviour and habits are formed solely by social interactions rather than by physical environment etc.

While digital technology develops at a galloping speed, humans by nature possess an innate resistance to change, and radical changes tend to be implemented incrementally throughout different phases. For instance, Serbian-American scientists Michael Pupin and Nikola Tesla (1922) extrapolated on the possibility of wirelessly communicating by means of videotelephony (although they would refer to this as "television") even though this type of technology would not be available until many decades later. In the words of Postman (1992, p. 7), technology "plays out its own hand", meaning that a technological development will eventually find its own use in a given context. At the same time, it is important to remember that the information spread by ways of digitalisation also redefines basic concepts such as knowledge and truth, while re-programming society's perceptions of what is important, of what is feasible, of what is real and that which is not. In this way, reality assumes new expressions through digitalisation. Winning people's hearts and minds will therefore be quintessential when it comes to introducing new digitalised features in society. This is on a fundamental level a slow process in itself due to the aforementioned resistance to change.

In a sense, radical change does not only mean that it is always merely about learning a new routine. The radical change may, in some cases, necessitate a paradigm shift. The information carried along with that means that one must abandon most, if not all, that was learned under the old paradigm, and replacing old facts with new facts and discarding large quantities of knowledge that has now been made irrelevant (De Toni, Siagri, & Battistella, 2021; Tinnerman & Johnson, 2011). It is not until one is able to acknowledge that the old facts are not able to accurately explain difficult phenomena that true change can occur in people's minds. This sacrifice is the pound of flesh that a paradigm shift requires from the people it is meant to serve. The added dimension brought on by digital technology in particular, is that it is not only a matter of replacing one truth with another, but the fact that this technology brings with it such a plethora of information that it is oftentimes difficult to discern which should be processed and which should be filtered out.

The dynamic nature of digitalisation means that "truths" are not necessarily stagnant for a longer period of time and that greater flexibility is necessitated from the people. It also means that old formulas for success quickly become outdated. We have long been taught that "old is gold", but in actuality "old is gone" (Kamdar, 2019, p. 56).

It is in human nature to seek out strategies and methods that are known to have been tested and that have been successful in the past. However, while the established strategies and methods may have worked within a certain era or context, not everything can withstand the test of time. In the end, new technology and new insights will render the old ways obsolete. One must also remember that change is the only constant, and this is particularly true in the event that there is an "anomaly" that disrupts society as we know it. When such occurs, there are two possible responses.

The first response will try to revert back to the familiar old system of knowledge for possible explanations and remedies, essentially fixing old theories and applying them analogously on other situations (P. L. Berger & Luckmann, 1966). This approach may work temporarily, but in time, the effects of this solution will begin to wane as it becomes gradually more apparent that the conditions that produced the old theory are no longer applicable to the given circumstance.

The second possible response will understand that the old approaches are no longer viable for the given situation, irrespective of whether there is an alternative approach in place to replace it or not. When this happens, a crisis occurs, which signals the need for a new way of thinking and for a different way to tackle the problem at hand (Jörg, 2014). The eruption of a pandemic such as COVID-19 perfectly illustrates the occurrence of such a crisis developing, where the decision makers of the world realised that conventional routines would not apply on the new situation and in multiple cases had to employ ad hoc solutions to many of the problems (Brglez, Udovič, & Maček, 2021). The pandemic exposed many flaws in a multitude of cities around the world and the weaknesses in their strategic ability to deal with the situation at hand, forcing many of them to quickly resort to new methods and practices. This included practices such as unprecedented lockdowns and stay-at-home orders etc.

While COVID-19 may have permanently changed society as we know it, the new order had not yet won over enough adherents to be able to function as a generally accepted go-to solution, as many citizens, politicians and experts continued to discuss their desire of wanting to return to the situation that existed before the pandemic, while debating how one, in some way or another, may patch up and repair the old system (Briggs, Ellis, Lloyd, & Telford, 2020; Sheth, 2020). In this way, neither the previously mentioned sceptics nor the enthusiasts were able to proffer a solution to the given situation, since the former would disavow the uniqueness of the situation and dismiss digitalisation as a means of bringing about change to the situation, and the latter would contend that change is already underway and will remedy everything via an "invisible hand". Instead, the situation of the COVID-19 pandemic illustrated that there is a need for a whole new approach towards digitalisation altogether. While slow-moving, digitalisation will need to gain the gradual acceptance of the general public before it can reach its full potential. Change will need to be implemented without additional delay, and old "truths" will need to be challenged.

3 Digitalisation and the Smart Cities

It is estimated that 22 billion IoT devices connected devices will be in use worldwide by 2025, with an estimation of 50 billion globally connected devices by 2030 (Chauhan, Avasthi, Alankar, & Kaur, 2021; Munk, 2021). Rather than serving as an optional tool for improving everyday life, digitalisation is nowadays so ubiquitous that it is oftentimes difficult, if not impossible, to conduct many of the societal functions without any form of digital technology. In the case of smart cities, digital technology is an integral and inseparable component of the very structure of the city design. That is to say, digital technology, such as smartphones, have in essence become the proverbial keys to the city inasmuch that they grant immediate access to essential information about matters such as public transport, traffic, healthcare, safety alerts etc. Cities reliance on digital technology was clearly manifested during the COVID-19 pandemic since it, in addition to spreading information, also enabled people to maintain their jobs and continue to use various services even in times of lockdowns and isolation.

On the face of it, digitalisation, as we know it, is to a large extent oriented towards processing large data streams and "Big Data". Big Data analytics, in particular, carry considerable potential to enhance smart city services (Al Nuaimi, Al Neyadi, Mohamed, & Al-Jaroodi, 2015). Nevertheless, Big Data can only be effective if it is implemented and understood correctly. There are various ways of addressing this issue, and while an exhaustive discussion on this topic is beyond the scope of this chapter, one possibility is to employ a "maturity model", i.e. a tool that seeks to assist in assessing the effectiveness of the tools used (Comuzzi & Patel, 2016). The main potential of applying Big Data in a smart city environment is that data can be processed rapidly and changes that can improve residents' quality of life can thus be implemented quickly (Alshawish, Alfagih, & Musbah, 2016).

In order to infer knowledge from the available information that has been collected and stored digitally, the data must be aggregated in a way, sometimes through models, that describes and generalises the findings in a perspicuous manner (Gray & Rumpe, 2015). Indeed, digitalisation affects all layers of society, including everything from personal relationships to the kind of interaction people have with the authorities and different government agencies. What then is digitalisation? In simple terms, digitalisation is the incorporation of digital technology into our everyday life. Specifically, digitalisation refers to a "process in which the use of digital/computer technology (also including mobile applications) by an organisation, company or society, etc. is adopted or increased" (Larsson & Viitaoja, 2017, p. 859). Much in the same way, the term "digital transformation" is a broader concept that signifies a strategic transformation that requires profound structural change beyond the mere implementation of digital technologies (Larsson & Teigland, 2020).

Cities are under increasingly more pressure globally, since cities are growing in population numbers by the day. This understandably places an even greater strain on the already limited resources and "public goods" such as clean water and air, and also on energy and liveable areas. In recent years, cities have sought to optimise themselves through digital technology. An increasing amount of infrastructure is constructed according to standardised building information management (BIM) software, which is defined as the "use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions" (Atkin & Brooks, 2021, p. 414). Moreover, smart grids are becoming a more viable alternative to the conventional energy networks as they have the ability to adapt swiftly to accommodate for variations in demands (Feng, Stoupis, Mohagheghi, & Larsson, 2012; Saleh, Althaibani, Esa, Mhandi, & Mohamed, 2015). To this end, various types of city infrastructures will become more interconnected in order to make city operations more efficient.

The infrastructure surrounding a smart city presupposes that there is wide integration between the IoT and cloud computing technologies (Jara, Genoud, & Bocchi, 2014; Serrano, 2018). The digitalisation of cities is commonly referred to as "Smart City 4.0" (Postránecký & Svítek, 2017; Yun & Lee, 2019). This is a reference to the adoption of "Industry 4.0", which, in turn, entails the ongoing automation of traditional manufacturing and industrial practices, using modern smart technology (Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014). "Smart City 4.0" essentially describes the impact of automation and data exchange on manufacturing. Applied to a city-specific context, this entails, for instance, that buildings actively connect with the energy grid and interface with mobility requirements, or that self-learning systems can provide data that can be used to improve the air or water quality in the city (Hwang, 2020; Postránecký & Svítek, 2017).

Digitalisation is a disruptive force (Dobbs, Manyika, & Woetzel, 2016). As such, digitalisation's main benefits in a city perspective are: (1) optimising infrastructure, and (2) securing productivity gains in industry and manufacturing. Digitalisation also enables the development of new services to further mankind's quality of life, thanks to the availability of data and the means of processing and analysing it in an efficient manner. Digitalisation is indeed a broad and widely applicable concept, so what do we mean when we talk about "digitalisation" in an urban context? Understandably, the applications are broad even in this context. Though among the more prominent uses, is that it can be used as a means to assist urban planners to create a digital replica of the physical work environment (Śledziewska & Włoch, 2021). This makes it immensely easier to plan and simulate improvements in design, engineering and automation of various processes, in addition to other miscellaneous forms of analytics. In short, the digitalisation of cities makes it possible to conduct simulations and predictive maintenance, which, in turn, makes it simpler to perform daily operations. In a smart city context, digitalisation is used in part to keep wasted time and resources to a minimum, and in part to improve productivity and growth, while also stimulating various economic activities.

4 Digitalisation in Times of Pandemics

The year 2020 saw a tumultuous start to a new era that would upend society's conception of "status quo" and impose a new mode of normalcy on the world amidst the already ensuing economic disruption and social unrest, namely the three "C"s of crisis: (1) *climate*, (2) *cyber*, and (3) *COVID-19* (Kanowitz, 2020; Sui & Shaw, 2021). These challenges have come to test humanity's resilience to its extreme and it has made people turn their eyes towards digital technology and how it can be used to better the lives of people and for society at large. The eruption of COVID-19, in particular, has illustrated that the digital transformation will need to be even further accentuated. Effectively, COVID-19 served as a catalyst for many new innovative applications of digital technology, for private citizens, companies and society in general (Akpan, Soopramanien, & Kwak, 2021; Islam, Islam, Hossain Uzir, Abd Wahab, & Abdul Latiff, 2020; Zahralddin-Aravena, Leduc, & Antle, 2020). With people isolated in their homes in quarantine, the need for robust and high-speed Internet became more important than ever, both for urban as well as for rural areas. As such, the pandemic issued increased calls for the development and/or application of new technologies and new synergies forming. One such example is autonomous vehicles that have the ability to transport people to places in autonomous cars, alternatively, have goods delivered to people using the same technology (Costa & Peixoto, 2020). Nuro, an autonomous grocery service, serves as a concrete example as it partnered up with Walmart to introduce automated grocery delivery in Houston, Texas (Jaffe, 2021). Also, the Mayo Clinic in Jacksonville, Florida used autonomous vehicles to transport COVID-19 test samples (Okara & Al-Turjman, 2021).

In this way, autonomous technology has a wide array of uses, and once implemented, they may well become permanent even once the pandemic subsides. The same can also be anticipated among various types of consumer behaviours. Unwilling to handle potentially virus contaminated money bills

Image 8.3 An autonomous bus transporting COVID-19 test samples at the Mayo Clinic, Florida, USA.

Source: Mayo Clinic.

and coins, people have, in great numbers, increased their use of cashless transactions, while e-commerce has also increased substantially, allowing people to keep themselves quarantined if necessary while still being able to make their purchases (Daqar, Constantinovits, Arqawi, & Daragmeh, 2021; Kulisz, Bojanowska, & Toborek, 2021). According to a McKinsey study in the US, another effect of COVID-19 is that it had adverse effects on brand loyalty as 75% of the population switched brands during the pandemic, which was caused by various retailers' inability to supply a given brand at a given time in their online stores (Arora et al., 2020). While online sales with automated processes might be picking up, there is, at present, still a lack of adequate support features. People are currently unable to get assistance fast, if need-be, to the same extent as through more conventional sales, and for this reason, we can expect further development on the side of chatbots in the future (Chung, Ko, Joung, & Kim, 2020; Sheth, 2020).

Still, on a more fundamental level, calls for better leadership and city planning propels the digital development even further. In the words of Barber (2013, p. 267), "Where cities go and citizens lead, there technology can follow, reinforcing and augmenting their progress in significant ways". While the development of new services and changes in behavioural patterns follow technological development in general, and during pandemics in particular, there is also a macro-perspective to consider, and how digitalisation can help decision makers plan better for the future of the city after a disaster has struck. To this end, new digital technologies, such as virtual reality (VR) and augmented reality (AG) may help planners to help design more resilient cities (Śledziewska & Włoch, 2021). A new, revolutionary, development beyond this technology is the creation of so-called digital twin cities (or virtual three-dimensional city replicas), which can be used to help tackle future emergencies (Allam & Jones, 2021; Cureton & Dunn, 2021).

5 Digital Twin Cities

Digital twin cities are sensing systems enabled by IoT, data analytics and machine learning, which are generally managed via control rooms or cloud and mobile open data platforms, with interactive virtual models that enable procedural testing and scenarios (Cureton & Dunn, 2021). A digital twin city could be used for purposes of real-time tracking of a pandemic's progression. As such, it could be used as a formidable platform for aggregating and distributing information at scale, while at the same time helping the authorities to assess and implement economic recovery plans for affected cities and urban regions (Allam & Jones, 2021; Cureton & Dunn, 2021; Teng et al., 2021). Projects aspiring to create "digital twin" of cities have been on the rise in later years, much thanks to the advancement of 3D modelling software. Also, the use of digital twin cities is becoming increasingly more prominent as more cities are turning into smart cities. Still, the eruption of COVID-19 effectively acted as a catalyst to inputting various types of essential data sets into crisis models, which, in turn highlighted the importance of extending and developing these models into full-fledged digital twin city models (Pang, Huang, Xie, Li, & Cai, 2021; Serbulova, 2021; Shahat, Hyun, & Yeom, 2021).

Khaled et al. (2020, p. 3) draw upon a description of the digital twin city as:

> [A]n up-to-date representation, a model, of an actual physical asset in operation. It reflects the current asset condition and includes relevant historical data about the asset. Digital twins can be used to evaluate the current condition of the asset, and more importantly, predict future behavior, refine the control, or optimize operation.

The raison d'etre behind developing a digital twin city is that it allows for the simulation of city plans before implementing them in practice (White, Zink, Codecá, & Clarke, 2021). This would pre-emptively expose potential problems before they ever come to pass while considerably improving the disaster management within cities. Digital twin cities allow for the planning analysis of various architectural aspects by means of digital tools, such as infrastructure, wireless networks antennas, solar panels, roads and public transport (Jones, Snider, Nassehi, Yon, & Hicks, 2020; Schrotter & Hürzeler, 2020). It also allows for better simulations and planning for potential "what-if" scenarios, such as in the event of disasters, war or pandemics etc. (C. Fan, Zhang, Yahja, & Mostafavi, 2021; Ford & Wolf, 2020). By creating a digital twin, government agencies and/or other decision makers are able to analyse what courses of action can be undertaken with the available city data in order to improve the standard of living, while reducing waste, expediting lead times and creating a more cohesive and integrated society. While the concept of digital twin cities is new for many cities around the world per se, its practice is anticipated to become mainstream in the near future (Chen, 2021; Deng, Zhang, & Shen, 2021).

A digital twin city has uses that reach far beyond mere crisis management, as they can also be used to model and simulate matters such as climate change, infrastructure planning and public health studies (Ketzler et al., 2020; Pang et al., 2021; Shahat et al., 2021). Using a digital twin, city planners can more easily model and accurately anticipate a city's street grids, transport networks, buildings and population and how any potential design changes would affect any of these areas. Moreover, it could also help account for any indirect consequences caused to any particular area by changes made in a different area.

Although visual 3D representations may provide the public with a wealth of information, there also needs to be an interconnected infrastructure in place in which various components are able to communicate with one another (Lafioune & St-Jacques, 2020). This means that there is an intricate system at work beyond the already comprehensive 3D modelling of the city. The 3D mesh is created by a reality modelling software, which is, in turn, linked to IoT enabled infrastructure components via a cloud-based IoT operating system (Al-Ali et al., 2020; Hämäläinen, 2020; Komninos, 2020).

In this way, the model is not only able to account for the surface buildings, but also for the city's underlying infrastructure as well. The city's underlying infrastructure layer, such as energy, water, security, transportation, healthcare and other types of edifices, provides information that is fed into a common data layer for the purpose of enabling analytics and making it possible to take preventive as well as prescriptive measures as necessary. The platform has capacity to process large quantities of data. The interface is based on open application programming, meaning that once data is made available, other innovators may find additional use to improve the lives of the city's residents or the local enterprises based on the available data, e.g. by developing new apps etc. (Qi et al., 2021).

In 2015, an ambitious €1 million (≈ US$1.13 million) project called the *Helsinki 3D+ project* was undertaken by a team of Finnish 3D developers to recreate a "digital twin" of the Finnish capital of Helsinki (Cousins, 2017; Cureton, 2021). Its ambition was to create a three-dimensional representation of the city using reality capture technology, with the added ability to provide geographic coordination, evaluation of options, modelling and visualisation. The premise of the Helsinki 3D+ project is to improve the city's internal services and processes, while also providing data for further smart city development (City of Helsinki, 2019; Del Giudice, 2021). The model uses technology that enables the user to examine the model online, access building information and conduct queries using it, while also downloading segments of the model in a set of commonly applied 3D file formats (Virtanen et al., 2018).

While the case of Helsinki is a fascinating case study in this context, it is by no means the only city that aspires to find new ways of collecting open data to enable and improve research and development on the City 4.0 concept. Another city that explores a similar concept, albeit in a different way, is Columbus, Ohio, having won the US-wide 2016 Smart City Challenge (Cocks & Johnson, 2021; Wang & Zeng, 2019). The *Smart Columbus* campaign, as it is called, aims to improve quality of life of the city's residents, while also driving economic growth and fostering sustainability etc. It does this by interconnecting infrastructure services, such as transportation, housing, and healthcare, to illustrate how cutting-edge technologies can work in real cities.

Virtual Singapore is another example of a dynamic 3D digital model that has been steadily developing since its announcement in 2014 with an initial budget of US$73 million, funded by the Singaporean National Research Foundation (Gassmann, Böhm, & Palmié, 2019; Shirowzhan, Tan, & Sepasgozar, 2020). It is intended to be used by urban planners and policymakers to visualise data, extracted from sensor networks and intelligent systems across the city in addition to providing the use of a building editor, so that it can assist them in making more informed decisions (Cousins, 2017; Yao et al., 2020). However, some of the disadvantages of this model in particular, is that it is thus far not publicly available (hence, citizens may not provide feedback data) and yet another disadvantage is that Virtual Singapore does not include urban mobility data (Charitonidou, 2022).

Researchers have also built a digital twin city of Herrenberg, a small city near Stuttgart, Germany (Dembski, Wössner, Letzgus, Ruddat, & Yamu, 2020). The researchers invited the city's residents to use an app in order to record their emotional responses to simulated scenarios in public spaces. With the aid of VR, approximately 1,000 denizens recorded whether they felt comfortable, happy or unsafe in any of the areas in question (Deckert, Dembski, Ulmer, Ruddat, & Wössner, 2020). The purpose was to investigate what it was that was commonly perceived as a "good public space" and then use that data to support city planners and architects to improve spaces in which the denizens did not feel the same level of comfort, such as areas with heavy traffic or dim lighting. The respondents involved groups from all walks of life, including women, seniors, immigrants and physically disabled people, many of whom that are commonly underrepresented among the usual test audiences (Dembski et al., 2020).

There are also initiatives to ensure a wider distribution of digital twin cities. In 2019, Chalmers University of Technology in Gothenburg, Sweden secured funding from the Swedish research funding agency Vinnova to set up the *Digital Twin Cities Centre* (Forssen et al., 2020; Pietrzyk, 2020; Vinnova, 2019). The centre consists of a broad consortium of 31 Swedish and international stakeholders, with the capacity to conduct cutting-edge research in a number of areas such as urban planning & design, architecture and digital construction (Digital Twin Cities Centre, 2021; Forssen et al., 2020). As of 2020, researchers from Digital Twin Cities Centre were engaged in wind simulations and visualisation based on a fluid solver, which refers to a type of computer graphics technique for generating realistic animations of fluids e.g. water and smoke (Bridson, 2016; Pietrzyk, 2020). The expressed ambition of the Digital Twin Cities Centre is to make Sweden a leading European country in the implementation and utilisation of digital twin cities and to ensure that digital twin cities are established as the foundation for digital planning, design, construction and management of sustainable, intelligent and inclusive Swedish cities and regions by 2030 (Digital Twin Cities Centre, 2021).

Digital twins are particularly useful for cities that are vulnerable to climate change, or are in otherwise environmentally risky areas, since problems can be simulated in order to find the most optimal solution. Digital twin cities can also be used to simulate the effects of factors such as regional migration and gentrification and, in addition, they do indeed have the capacity to model effects of pandemics. Since pandemics affect city functions on so many different levels, digital twin cities would be an advantageous way to try and anticipate the effects of any and all proposed courses of actions in any given major city.

6 Conclusion

The aim of this chapter was to explore how smart cities can leverage the benefits of digitalisation to relieve pressure on extant services and resources following a pandemic such as COVID-19.

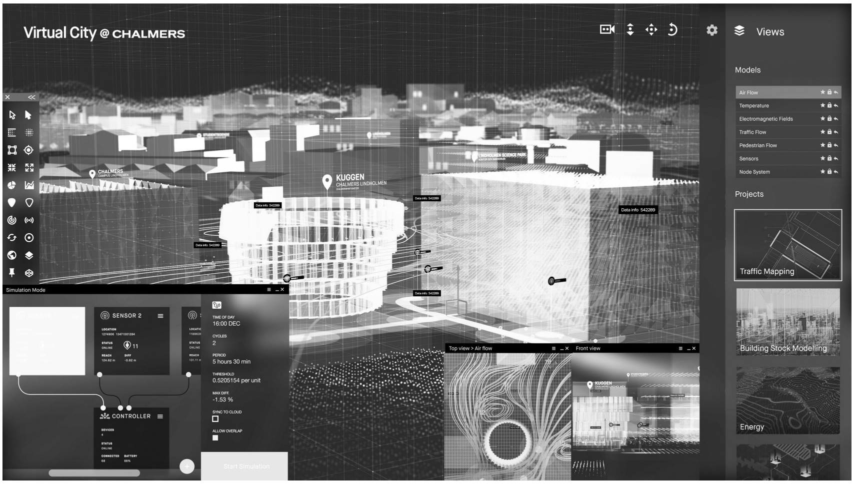

Image 8.4 Illustration from the Digital Twin Cities Centre at Chalmers University of Technology, Gothenburg, Sweden.
Source: Digital Twin Cities Centre, Chalmers University of Technology.

Action 1: Technology Progresses at a Relatively Slow Pace and Strategies Need to be Designed with this in Mind

As initially stated, one of the chief proponents behind developing technology is the desire to communicate and exchange information better. While digital technology should not be viewed as a panacea against conflict on a general scale in all given circumstances, the enhanced means of communication and the information it brings, can help improve the preconditions of managing problems, and sometimes even pre-empting them before they occur. However, the advancement of technology is still progressing at a relatively slow pace due to new concepts requiring introduced and to be learned by those for whom it is intended. As such, any new strategies undertaken will need to take a long view and bear this fact in mind.

Action 2: Strategies Need to be Prepared for the Continuation of Automation and Cashless Transactions Even after the End of the Pandemic

The eruption of COVID-19 has prompted many of the envisioned changes at a much faster pace than originally intended and has perhaps made some permanent changes to the structures of our cities. Two of the most ostensible and imminent changes have been the use of automated services and the decreased circulation of cash, in favour of cashless transactions. These changes can be expected to continue, even after the pandemic has ended, as the wheels have already been set in motion, and future planning needs to account for this development.

Action 3: VR/AR and Digital Twins Will Lead the Way

More advanced and widespread use of VR/AR can also be expected, as well as the development of more sophisticated chatbots. Going forward, the most anticipated innovation in digital technology for smart cities will undoubtedly be the development of the digital twin cities. These virtual models have the preconditions to help revolutionise crisis management not to just help future-proof cities for pandemics, but also to help resolve contemporary pressing matters as well, such as planning for emission, traffic control, public transport, housing, power grids etc. The development in this area is progressing steadily, albeit slowly, with more cities picking up an interest in developing a digital replica of itself. To this end, digital twin cities should have a given place in all major cities as they can help revolutionise urban planning as we know it, particularly in planning courses of action in how to deal with pandemics during its progression as well as with their aftermaths.

Concluding Remarks

Digitalisation is essentially what lies at the heart of any smart city. Still, digitalisation is by no means a self-sufficient entity. It must be sustained and developed continuously in order to ensure efficacy but it is not always a swift process. Hence, devising future strategies to strengthen pandemic resilience will need to account for the fact that a digital transformation of society will likely be a slow and arduous process. Still, innovations such as digital cities can help revolutionise our urban planning and, by extension, also our capabilities of protecting ourselves over time and in preparation of future possible pandemics. It is true that digital twin cities are slow and unwieldy to develop and that any possible pandemic or comparable large-scale disruption occurring over the span of the next few years would likely have long since passed by the time most cities would be able to develop a digital twin city. However, this fact should not be used as an argument to eschew the development of digital twin cities, as they may prove invaluable for urban planners and epidemiologists ahead of future pandemics.

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9 Safety and Security

Identifying and Addressing Crime in a Pandemic Smart City

1 Introduction

There is no question that need for safety and security are integral components to every city, and/or society. This follows Maslow's (1943) hierarchy of needs, which identifies "safety needs" as a basic need, placing it as the second most important need to mankind overall after strictly physiological needs for survival, such as food, water, warmth and rest. Unmitigated crime, or the perception thereof, adversely affects the comfort of denizens and it is known that the fear of victimisation not only affects the city's attractiveness in terms of people's propensity to live (or not to live) there, but it also imposes additional indirect costs to society through its negative impact on local business establishments (Cohen, 2008; Greenbaum & Tita, 2004; Matti & Ross, 2016). Many different criminological theories have been presented throughout the years of how to best mitigate the prevalence of crime while instilling a sense of security among the city denizens. One of the more renowned contemporary theories towards this end is the "broken windows theory". This theory stipulates that visible signs of crime, anti-social behaviour and/or civil disorder create an urban environment that fosters further crime and disorder (Wilson & Kelling, 1982). As per this theory, more serious crime can be pre-empted by targeting minor crimes. This includes vandalism, loitering, public drinking, jaywalking and fare evasion etc. By doing so, one helps create an atmosphere of order and lawfulness. While the theory is admittedly contentious according to some, there has been scientific support that it may lead to consistent crime reduction effects (Braga, Welsh, & Schnell, 2015; Keizer, Lindenberg, & Steg, 2008). Regardless, the "broken windows theory" has conventionally targeted crimes that are more "ostensible" to the naked eye. While these crimes do exist and will continue to exist, times are also changing and so are the ways in which some crimes are perpetrated.

As smart cities have become more technologically advanced, the dependency on modern technology has become all the more real. Technology provides essential tools for emergency services as well as for various means of security mechanisms aimed at protecting the city denizens as well as society at large. Nevertheless, there is a flipside. The increase in connectivity and

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"smart" technologies, by the same token, also means that the city is effectively more vulnerable (Ismagilova, Hughes, Rana, & Dwivedi, 2022). To this end, not all types of crime are as ostensible, or visible, as they were in days prior to digital technology. Yet, these crimes also have a negative impact on city residents and businesses, and in this sense, the underpinnings of the "broken window theory" are also salient for digital/online/cybercrimes (Rao, Pradhan, Panda, & Rath, 2020; The Computer Security Team, 2019). A lack of proper network segmentation as well as inadequate password management and a vulnerable e-mail security are all factors that can act as "broken policies" (Van de Giessen, 2021; Wallace & Webber, 2022).

The risk of cyber-attacks is a problem that is specifically inherent to society's digital transformation. The consequences of such attacks can be dire indeed considering that various city-based authorities contain sensitive personal information about their denizens. This is data that is desirable for hackers to gain access to for various maleficent purposes. Alternatively, the data runs a risk of becoming compromised in other ways unless safeguarded properly. By the same token, the physical safety of denizens must also be upheld. More than that, a smart city cannot be truly "smart" unless it is also "safe". To this end, the sense of safety and crime prevention actually constitutes two essential key elements to ensure the sustainability and resilience of smart cities (Bibri, 2019). In this context, sustainability is characterised by the smart city's ability to utilise information and communication technology (ICT) towards transforming society and the social lives of its denizens while conserving as many of the natural resources as possible (Vogiatzaki, Zerefos, & Hoque Tania, 2020). "Resilience" is, in this context, characterised by something more than mere survivability, as it is rather more akin to an adaptive ability to learn and improve from detrimental events, such as pandemics and crime waves etc., in order to become more responsive to similar occurrences in the future (Evans, 2013).

In order for a city to thrive, the well-being of the city denizens must be an imperative attribute, one that is particularly salient in times following a pandemic. This is a time where nefarious criminals will not hesitate to make cynical use of the turmoil, unrest and vulnerability triggered by the pandemic. This, in turn, causes the risk of crime rates in the city to skyrocket if not dealt with effectively and, preferably yet, even pre-emptively. Thus, the aim of this chapter is to explore how physical and digital security can be safeguarded in a smart city and how it can be used to strengthen resilience. As a pandemic case, this chapter will, for illustrative purposes, look at the events transpired during the COVID-19 pandemic. While the COVID-19 pandemic occurred concurrently as many other incidents in cities worldwide, such as most notably, the 2020–2021 protests relating to the racial unrest in the US, and to some extent even the 2022 Russian invasion of Ukraine, this chapter is concerned with matters pertaining to the safety and security issues caused and resulted by the COVID-19 pandemic (Arel & Driscoll, 2022; Rosenfeld & Lopez Jr., 2020).

2 Types of Crime during a Pandemic

2.1 The Changing Nature of Crime during Pandemics

It is unfortunately an inevitable fact that anywhere, where there are societies of people, there is also crime. However, during pandemics, societies are impacted in different ways and therefore there is a need to adapt to the new order of things in several different layers. This also applies to criminality, which will find new ways of sustaining itself. To this end, studies have shown that the nature of crime tends to change during times of pandemics, something that was most notably seen on a grander scale during the COVID-19 pandemic (Stickle & Felson, 2020).

The pandemic showed a positive impact on bringing down certain types of criminal activity, due to restricting the opportunities for such crimes. Needless to say, however, the pandemic did not have exclusively positive effects on bringing down the crime levels, as organised crime tended to neither increase nor decrease, while other types of crimes saw an upswing (Balmori de la Miyar, Hoehn-Velasco, & Silverio-Murillo, 2021). Moreover, studies show that the crime that did decrease during the imposed social restrictions, tended to increase again once the restrictions were lifted (Andresen & Hodgkinson, 2020; Estévez-Soto, 2021). Nevertheless, the pandemic prompted an increase in "digital mobility" with a greater number of people working remotely and people resorting to online, digital solutions to compensate for the loss of their physical leisure activities. To that end, the format in which crimes were typically committed began taking a new turn. While in no way an exhaustive list, the following section discusses some of the most notable areas of impact the pandemic had on certain types of crime, with some illustrative examples from different countries and cities.

2.2 Types of Crimes Possibly Decreasing during the COVID-19 Pandemic

2.2.1 Serious Assault in Public Places and Public Disorder

Specifically, pandemic-related mobility restrictions such as lockdowns and social distancing in general have had considerable effects on both physical and digital crimes. In the UK, for instance, serious assault in public places and public disorder crimes, such as bar fights etc. decreased in 2020 during the COVID-19 pandemic, where restrictions on pubs, restaurants and public entertainment areas were launched in March 20, 2020 (Farrell, 2020). However, this only appears to have applied to certain types of assaults in public places. In contrast, research from the US shows there was no overall systematic change over the frequency of serious assaults during the early weeks of the COVID-19 pandemic (Ashby, 2020). One explanation for this is that serious violence is generally perpetrated by a smaller number of repeated offenders and is usually subjected to repeat victims (Jennings, Piquero, & Reingle, 2012). Studies have shown that offenders committing serious offences are also more prone to committing minor infractions as well, e.g. violating curfews or stay-at-home orders (Roach, 2019). To this end, it is likely that the belligerents engaging in serious assaults are as likely to take to the streets whether there is a pandemic present or not. Nevertheless, results from the Californian cities of Oakland and San Francisco show that there was an overall drop by approximately 40% of reported cases across the communities and crime categories in both cities (Shayegh & Malpede, 2020). This drop would continue throughout 2021, though depicting a somewhat erratic overall view of California, since the general crime rates in cities such as Long Beach, Sacramento, San Diego and San Jose actually increased as compared to 2020 (Males & Washburn, 2021).

2.2.2 Most Types of Property Crime

Shoplifting effectively plunged after the British government mandated all non-essential shops to close on March 23, 2020, which, during its first round, would last until June 15, 2020, although subsequent periods of lockdowns would follow throughout the year and during 2021 (Buil-Gil, Miró-Llinares, Moneva, Kemp, & Díaz-Castaño, 2021; Farrell, 2020; Institute for Government Analysis, 2021). This also meant that robbery, theft and domestic burglary dropped considerably during 2020 as there were fewer people roaming the streets (Buil-Gil et al., 2021; Casciani & Butcher, 2021). It follows that if people are confined to their homes, there will be fewer opportunities to perpetrate the aforementioned types of crimes. In fact, as of September 2020, the overall police recorded crime saw its biggest annual decrease since 2010 in the UK, albeit with some variations by specific offence (Casciani & Butcher, 2021; Kantar, 2022). Data from the US indicated a similar trend across several metropolises (Abrams, 2021). For instance, in Chicago, Illinois; Los Angeles, California; and Memphis, Tennessee burglary decreased considerably during 2020, to approximately half the levels of what was initially forecast (Ashby, 2020). Still, there were some exceptions. For instance, in Austin, Texas; Louisville, Kentucky; and Minneapolis, Minnesota, the burglary frequency largely followed the forecasted models, although there was no obvious explanation as to how there could be such an inconsistency of burglary trends across the different cities (Ashby, 2020). As illustrated later in this chapter, there were other types of property crime that did not decrease, but rather the opposite.

2.3 Types of Crimes Increasing during the COVID-19 Pandemic

2.3.1 Scams

Supposedly, the first instance of a documented fraud attempt occurred around 300 BC, when Hegestratos, a Greek merchant, tried to sink his ship in order to collect insurance money but was chased off the ship and drowned when his crew caught him in the act of attempting to sink the ship (Subramanian, 2014). Various forms of fraud were facilitated by ways of the pandemic, especially those conducted online or via the phone. Schemes would include purported offers to purchase "COVID-19 vaccines" and acquiring a dose ahead of the general population, or other types of fraudulent offers pertaining to medicine, insurance offers and so forth, in addition to the more "conventional" types of fraud offers, concerning counterfeit goods and certifications etc. (Choudhary, Priyanka, Singh, Mohammed, & Rodriguez-Morales, 2021; Kassem & Betts, 2020)

The classic "419-scams", more commonly known as the "Nigerian letter frauds" (and derivative variants thereof) also saw an increase during the pandemic (Deutsch, 2021; Dobrinoiu & Gratii, 2021). In short, the scam involves the victim being solicited by a fraudster either via letter, e-mail, social media or phone etc. The victim is offered an "opportunity" to share a percentage of a specified number of millions of dollars that the fraudster (purporting to be an esteemed person of repute or representing someone in high authority) is intending to transfer from a foreign country. However, the fraudster claims to be unable to do so by their own device due to various convoluted circumstances, which often involves either legal or physical restrictions that the victim can somehow bypass since they are purportedly not affected by any of these supposed restrictions. Once contact has been initiated, the fraudster insists that the victim send information to the fraudster, often including material containing their bank name and account numbers, and/or other types of sensitive information. The success of this con builds on forming an emotional relationship with the victim (Holt, Bossler, & Seigfried-Spellar, 2018). Thus, the scam is contingent on the victim becoming a willing participant (at least initially) who acts in an interest to quickly enriching themselves, as several actions are needed on the victim's part. This includes responding to the fraudster's message, and ultimately sending them money out of their free will in several instalments with the fraudster always insisting on additional payments (often with increasing amounts) for a variety of cited reasons (Erbschloe, 2020).

During the COVID-19 pandemic, these types of scams took on a new twist with con artists attempting to pass themselves off as government representatives, such as for the Internal Revenue Service (IRS) (or its equivalent in other countries), claiming to issue updates and payments on the authority's behalf (Internal Revenue Service, 2021). Other cons included fraudulent financial offers, where the fraudsters pose as banks, debt collectors or investors with offers designed to obtain people's financial information (Mahdzan, Sukor, Ismail, & Rahman, 2020). Yet, another con involved fake non-profit donation requests, where the scammers purport to have set up non-profits, hospitals, and other organisations to collect funds, thereby exploiting people's good will to donate to charitable causes such as disaster relief (Fontanilla, 2020; Wasik, 2020).

The victims were by no means a homogenous group, and the types of fraud varied immensely, and the fraudsters did not always present themselves as authoritarian or otherwise reputable figures (Kemp, Buil-Gil, Moneva, Miró-Llinares, & Díaz-Castaño, 2021). This was exemplified in the increase in various types of "romance frauds", which was the unfortunate result of combining the availability of digital technology with social hunger in the wake of extended periods of social distancing. While "hunger" may seem like a strong word in this context, studies have shown that the sense of loneliness is psychologically distressing for many, and may, in some cases, even carry physically ramifications such as increasing the likelihood of a premature death by some 26% (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015). To this end, studies conducted on the neural underpinnings of isolation have suggested that many people felt literally "starved" for contact amid the COVID-19 pandemic (Denworth, 2020). This, of course, was cynically capitalised upon by scrupulous fraudsters conning love-thirsting individuals who took to online dating apps in the hopes of finding love during a time of social isolation. According to reports by UK Finance (2021), there was a 20% increase in bank transfer fraud linked to romance scams in 2020 compared to 2019. This corresponded to an approximate US$94.1 million (£68 million) lost to such scams during 2020, with the total value of these scams increasing by 12% annually to US$25.6 million (£18.5 million) between January and November 2020, with victims losing US$10,864 (£7,850) on average (Giordano, 2021; Wakefield, 2021). According to the reports, victims were scammed via bank transfer, money transfer, faux cryptocurrency schemes, sending fraudsters gift cards and vouchers or presents, and/or providing them with access to their bank account or bankcard (Chaganti, Bhushan, Nayyar, & Mourade, 2021; Ma & McKinnon, 2022; Pritom, Schweitzer, Bateman, Xu, & Xu, 2020).

Other risks include falling victim to money laundering schemes, or "money muling", where unsuspecting victims are duped into moving money into their own account and then on to a stranger's account (Esoimeme, 2021; Raza, Zhan, & Rubab, 2020). This practice is particularly perilous as the victim may actually face a severe prison sentence on behalf of the criminals if caught (Raza et al., 2020).

2.3.2 Identity Theft

Identity theft doubled during the pandemic. In the US, the Federal Trade Commission (FTC) reported 1.4 million records of identity theft incidents occurring in 2020, twice the number of cases reported in 2019 (Skiba, 2021). Approximately 394,280 incidents were associated with unemployment insurance benefits, as opposed to 12,900 incidents reported in 2019 (Hope, 2021; Muncaster, 2021). In fact, most cases of identity theft were aimed at government relief funds reserved for those individuals and small businesses that had been the most affected by the pandemic (Hope, 2021). After the US government expanded unemployment benefits to people who had lost their job following the pandemic, unscrupulous cybercriminals filed unemployment claims using personal information belonging to other people. The perpetrators would also use victims' personal data to acquire government-sponsored loans reserved for small businesses affected by the pandemic. The deeds would often come to the victims' attention only after they would begin to receive repayment notices. All in all, it is estimated that in the US, roughly US$3.3 billion was lost through identity fraud in 2020, as opposed to US$1.8 billion in 2019 (Federal Trade Commission, 2021).

Likewise, millions of dollars were swindled through business e-mail compromises (BEC), which denotes a type of e-mail fraud used to target commercial, government and non-profit organisations with e.g. invoice scams and spoofing attacks designed to gather data for other criminal activities (Bakarich & Baranek, 2020; Goodchild, 2018; Hope, 2021). One of the most notable was the Nigerian-based cybercrime ring "Scattered Canary" that would use stolen personal information to file fraudulent relief and unemployment claims across multiple US states (Kioko & Marlowe, 2020; Newman, 2020). In many cases, scammers took advantage of absent or outdated/ineffectual identity verification systems, for instance, knowledge-based authentication (e.g. "In what city were you born?") or social security numbers rather than more advanced digital authentication systems utilising biometric data, such as fingerprints, retina scans or facial recognition systems etc. (Hope, 2021; Saračevič, Elhoseny, Selimi, & Lončeravič, 2021).

2.3.3 Specific Types of Property Theft

As mentioned earlier, most types of property crimes plunged during the pandemic. However, there were certain exceptions for specific types of thefts that would go against the grain and actually see an upswing. Specifically, during the pandemic, certain products became scarce. In rudimentary economic terms, this meant that the demand was greater than the supply, ergo, the prices would increase. This entailed that the likelihood of theft (or even robbery) suddenly escalated, particularly so for desirable items. For instance, USA Today reported that "Cargo thefts of hard-to-find paper goods, personal protective equipment and food soared in 2020 as the black market for such items flourished during COVID-19" (Bomey, 2020, para. 2). In Sydney, Australia, a 34-year old man was charged in September 2020 for having broken into a factory and stolen some 1,350 bottles of hand sanitiser and face masks, at an estimated value of more than US$5,400 (Dobeson, 2020). However, the pandemic also encouraged more casual and opportunistic occurrences of theft, possibly by people who would not otherwise engage in theft or at least not in a similar massive scale. For instance, there were widespread reports from hospitals in cities worldwide that visitors would steal hand sanitising gel on a daily basis, even going to the extent of ripping down wall-mounted dispensers (Ulke, 2020).

Even more exceptional types of thefts and contraband became more occurring during the COVID-19 pandemic. For instance, the loneliness felt by many people during lockdown have prompted them to purchase pets. This led to a skyrocketing demand for dogs, with soaring prices as a result (Waters, 2021). Organised crime began exploiting this situation by smuggling puppies from abroad and stealing dogs in the UK (and in other places) resulting in dog thefts ending up at an unprecedented high, with puppies stolen for immediate sale and adult dogs taken for forced breeding on puppy farms (Hawkins & Brodie, 2020).

2.3.4 Motor Vehicle Theft

While the number of car thefts appeared to decrease in Chicago, Illinois and Tucson, Arizona, the overall trend indicated that motor vehicle thefts increased during the pandemic (Ashby, 2020; Gorzelany, 2020). The National Insurance Crime Bureau (2021) reported that the number of stolen cars in the US in 2020 increased by 9.2% compared to 2019. For instance, in Austin, Texas and Los Angeles, California, the number of reported vehicle thefts increased significantly in first few weeks after lockdown, while the increase would taper off after a couple of months of lockdown (Ashby, 2020). As fewer motorists were taking to the roads, and effectively leaving their vehicles parked unattended for days, weeks or even months at a time, thieves were presented with an opportunity to better select their targets with great abandon (Gorzelany, 2020).

2.3.5 Anti-Social Behaviour

The volume reported crimes linked to anti-social behaviour increased drastically (Farrell, 2020). The COVID-19 pandemic instigated the introduction of new laws limiting social interaction and mobility, hence many of these offences concerned violations of curfew, not wearing masks in public or violating other types of government, state or city regulations (Sandberg & Fondevila, 2022). In addition, waste-related crimes, such as fly-tipping etc. increased in different cities due to mismanagement of various processes such as poor efficiency of source-separated waste collection schemes in urban areas, prevalence of landfills as a main waste management option, delays in implementing regional integrated waste management systems, lack of reliable waste statistics databases, and so forth (Farrell, 2020; Mihai, 2020).

In some Latin American countries, such as in some Brazilian communities, people began to block roads unlawfully in order to prevent the further spread of the disease (Menton, Milanez, Souza, & Cruz, 2021; Sandberg & Fondevila, 2022). Moreover, more than 600 attacks on healthcare workers out of fear of infection were reported from various countries including Pakistan and Bangladesh, while looting and other similar crimes occurred in the backwater of the unfolding crisis (Devi, 2020; Sandberg & Fondevila, 2022).

2.3.6 Shootings

Overall, the COVID-19 pandemic caused a temporary increase in fatal shootings and a long-term increase in all types of non-fatal shootings and gang-related shootings in the US (Kim & Phillips, 2021). For instance, in Philadelphia, Pennsylvania the number of shootings increased 7% since the state mandated its stay-at-home order from April 1, 2020, to April 15, 2020, compared to the same time period the preceding year (Boserup, McKenney, & Elkbuli, 2020; Wolf, 2020). However, firearm fatalities increased significantly in the entire US on average, with a 16% increase in April 2020 and a 15% increase in May 2020, as opposed to the same corresponding months in 2019, in spite of the fact that Americans spent their days staying at home (Gun Violence Archive, 2021; Stahl, 2021). To further exemplify, New York City, which was dubbed "the capital of the world" by Pope John Paul II in 1995, saw a 100% surge in criminal activity in the scope of one year, most of which were shootings and gang-related violence (Barron, 2021; Dunford, Keeling, & Rosenberg, 2011). The US as a nation was wracked by a record high 610 mass shootings in 2020, leaving almost 20,000 people dead from gun violence, while nearly 24,000 people died from suicide by gun (Pomeranz & Ochoa, 2021; Wamser-Nanney, 2021).

The reasons why COVID-19 has led to an increase of shooting has largely been attributed to a number of different factors. One purported reason is that the COVID-19 pandemic led to a massive disruption in everyone's lives, including everything and anything from the economy and entertainment, to the way we conduct our work. This sudden impact on the human way of life prompted people to change their behavioural patterns and routines as well, in some cases even to the extent that it led to more violent reactions and/or altercations. To this effect, there exists some prior, pre-COVID-19 evidence that shows that isolation and idleness increases crime, lending truth to the proverb that "idle hands are the devil's workshop" (Jacob & Lefgren, 2003, p. 1560). Instead of being at work or school, individuals will have more time to spend in being in gangs or partaking in illegal activities (Ballester, Zenou, & Calvó-Armengol, 2010; Jacob & Lefgren, 2003). As the COVID-19 pandemic shut down much of the day-to-day life, including schools and various types of work (often low-skilled jobs), those circumstances were more prevalent to many people in 2020–2021, and may have resulted in more acts of violent crime (International Labour Organization, 2021; Lopez, 2021).

Furthermore, many Americans brought a record number of guns in 2020 (23 million, or a roughly 65% increase compared to 2019) in a likely response to the perceived and actual threats that emerged in the form of chaos and unrest brought on by the pandemic (Halbrook, 2021; Nelson, 2021). According to a study, there was a significant increase in firearm-related violence in the US correlated with the COVID-19 pandemic-related surge in firearm purchases (Schleimer et al., 2021).

2.3.7 Domestic Violence

Measures implemented to control the spread of disease led to many people becoming isolated, sometimes in a toxic environment, which served to worsen their condition (McLay, 2022). Isolation may, to this end expose or worsen vulnerabilities, especially for those already subjected to intimate partner violence, since the pandemic also impacts the ability for established social support systems to function optimally. Quarantine conditions are associated with detrimental effects such as alcohol abuse, depression and post-traumatic stress symptoms (Brooks et al., 2020). Hence, stay-at-home orders may force people plagued by domestic violence into a disastrous setting from which there is neither escape nor reprieve (Boserup et al., 2020; McCrary & Sanga, 2021). This is indeed a globally recurring phenomenon. Data from the local police near the epicentre of the COVID-19 eruption in China's Hubei province show that instances of domestic violence tripled during February 2020 as opposed to February 2019 (Fraser, 2020). In France, occurrences of domestic violence increased by some 30% following the lockdown mandated on March 17, 2020, while the corresponding increase for Spain was 18% (Duncan et al., 2020). Argentina saw a 25% increase following its March 20, 2020 lockdown, whereas in Colombia, calls to the national women's hotline were up by roughly 130% during the first 18 days of the country's quarantine (Lima, 2020). In Singapore, there was a 33% increase of pandemic prompted instances of domestic violence, while the corresponding increase in Cyprus was 30% (Boserup et al., 2020; Williamson, Lombard, & Brooks-Hay, 2020).

The correlation between the increase of domestic abuse and the increase of people mandated to stay at home is visible not only on a national level but also on a city level. For instance, in Portland, Oregon, comprehensive schools closed on March 16, 2020, and on March 23, 2020, the stay-at-home orders were enacted (Brown, 2020). After these events, the Portland Police Bureau recorded a 22% increase in domestic violence-related arrests compared to the weeks prior (Boserup et al., 2020). In San Antonio, Texas and New York City, New York, schools were closed down in mid-March with ensuing stay-at-home orders a few days later (City of San Antonio, 2020a; Cuomo, 2020). The reported instances of domestic violence increased 18% and 10% for each city respectively (Boserup et al., 2020; City of San Antonio, 2020b; New York City Police Department, 2022). In contrast, a study from Texas suggested that the increase in domestic violence had been increasing already before the lockdown, making the correlation somewhat more vague (Piquero et al., 2020). However, another study showed that dispatch calls coded as "domestic arguments" (denoting a category that will normally not render an arrest) more than doubled in US cities during the lockdown compared to the same time period in the pre-COVID year of 2019 (Boman & Gallupe, 2020).

3 Addressing Crime

3.1 The Social Contract – Keeping Our Cities Safer with Technology

In *The Death and Life of Great American Cities*, Jane Jacobs (1961, p. 35) postulated a natural surveillance strategy that she referred to as "eyes on the street". This principle, which took its point of departure from her work in New York's Greenwich Village, essentially stipulates that cities, or neighbourhoods, can be designed in such a way that it mitigates crime. Examples may include low landscaping, street lights, removing potential hiding places for prospective burglar and assailants and so forth, with the intention of forcing the would-be criminal to have to perpetrate their crime in full visibility of the locals and thereby rather opting to abstain from the criminal act. However, in times of pandemics and social isolation, "eyes on the street" would carry less significance as oftentimes fewer people (if any) would be present in the immediate vicinity anyway. Also, as will be elaborated further, the digital technology has enabled other types of crime that is not easily combated by merely redesigning the neighbourhoods' architecture. In many ways, denizens will still rely on the "social contract". In the broad sense of the word, the "social contract" protects the rights and safety of the citizens in exchange for the acceptance of certain obligations to society and those in power. A typical example is how we accept the premise a tax system where we set apart a portion of our earnings and profits, and add a specific sum to the cost of things to pay the state in exchange for the state offering to provide safety and welfare for its citizens (Moore, 2008).

For the welfare state, upholding the social contract means walking a tightrope, where multiple aspects need to be accounted for. As contended by Blix (2020, p. 150): "For the welfare state, the balance of protection against a potentially destructive change and the promotion of innovations have from the outset been a central but fragile state of affairs." That is to say, on the one hand, too lax response to crime will make people feel less secure and thus undermine the social contract, while the implementation of too harsh security protocols will deprive citizens of their sense of freedom and rights, which would also serve to undermine the social contract. As famously expressed by Benjamin Franklin (1759, p. 289): "Those who would give up essential liberty, to purchase a little temporary safety, deserve neither liberty nor safety." In this way, digitalisation provides new tools and methods that have come to affect some of the fundamental building blocks of fighting and/or preventing crime. For it is true that combating crime is a never-ending battle. For the most part, it falls on the cities' jurisdiction to ensure the safety of its denizens and the sanitation of criminal elements. As discussed earlier in this chapter, it is established that pandemics such as COVID-19 alter the occurrence of certain types of crime. Hence, the question is rather how one may adopt/implement digital technology and/or new routines in order to combat these elements and thereby ensure that the social contract is upheld? In this, crime exists in both a "physical" form and a "digital" form. Possible ways of addressing crime are addressed in the following sections.

3.2 Digital Protection

A sign of the digital times is the need to keep people safe not only in the physical sense but also digitally. In recent years, a number of measures have been taken to increase personal safety online and to ward off scammers. Still, it is sometimes a relentless struggle. For instance, spam filters in our e-mail services are supposedly able to block e-mail scam letters from ever reaching us. Nevertheless, criminals are still able to manoeuvre around them by "personalising" their mails by addressing the recipient by their name or by using any other type of information they may have gleaned about them from the Internet and/or by grooming their victims over time (Dhavale, 2017; Konnikova, 2016).

This means that new approaches are needed in order to detect and block spam mails by potential scammers. Some companies, such as California-based ZapFraud (2016) even offer their customers a "fraud firewall". Solutions such as these are built on natural language analytics. This means that rather than flagging specific keywords, the algorithm identifies various narrative patterns that are indicative of fraud. For instance, a mail reaching out to someone following a purported sudden and unexpected event, along with the mention of a sum of money while stressing the urgency of the recipient undertaking swift action would be a typical example of an aforementioned "419-scam". To this end, natural language processing (NLP) may proffer a useful tool in the endeavour of stymieing such scam attempts. Specifically, NLP is a field of artificial intelligence (AI) that combines computational linguistics with statistics and models, giving machines the ability to automatically read, understand and derive meaning from human languages (Chiu & Baker, 2020; Eisenstein, 2019). The development of underlying computational hardware such as the Google-developed tensor processing unit (TPU) has led researchers to make leaps and bounds in the area of NLP and has enabled the development of cutting edge language models (Li & Liewig, 2020). The development of NLP has proven to be efficient in detecting fraudulent insurance claims etc. as well (Van der Aa & Leopold, 2021). Given the number of insurance claims and the extensive amount of background information verification needed in many instances, it is neither feasible nor efficient for human insurance agents to review all of the claims manually.

Notwithstanding, the technology behind NLP is by no means flawless at its present stage, as it still wrestles with problems concerning ambiguity, figurative speech, sarcasm, co-reference, synonymity etc. (Pilehvar & Camacho-Collados, 2021). While much NLP technology exists already today ready for deployment and as a useful means of interpreting information embedded within terabytes of unstructured text, more work is still needed to perfect the technology to overcome the aforementioned challenges.

Similarly, the increase in online "romance scams" stretches beyond the purview of any single city and is a concern that will ultimately require the collaboration of the service providers (Edwards et al., 2018). Possible future solutions in this domain include developing AI algorithms that are trained on labelled data and possess the ability to "learn" which content is unwanted (Suarez-Tangil et al., 2020). Automatic filters with the ability to check for specific IP addresses and specific phrases and so forth may also ward off some of the scammers. However, a more short-term remedy will lie in the reliance on human moderation by agents trained specifically to detect confidence tricksters operating on various online dating services, until the digital technology is perfected.

There is no panacea against identity theft, and it will most definitely remain a problem even in the future. What the countries and cities can do, is to make it more difficult for identities to be stolen and this means taking a multidisciplinary approach and adopt different technological solutions best suited for the given circumstance. These solutions will virtually always involve some form of encryption and multi-factor authentication, meaning authorisation is based on either of the following (Bizzell, Clinton, Prentice, & Stone, 2011; Dasgupta, Roy, & Nag, 2017):

- Something the user *knows*: e.g. password, PIN, security question answers.
- Something the user *has*: e.g. access cards or other hardware device with built-in authentication.
- Something the user *is*: e.g. fingerprint, voice or iris.

In Sweden, BankID (2021) has existed since 2003. Owned jointly by seven of the largest Swedish/Scandinavian banks, BankID proffers an electronic identification system for Swedish citizens and permanent residents (BankID, 2021; Essén & Ekholm, 2020). BankID is available on smart card, computers, mobile phones and tablet devices. As of April 2021, BankID had 8 million users, or approximately 80% of all Swedes, whereas roughly 98% of the Swedish population between the ages of 18 to 67 possessed a BankID account (Wemnell, 2021). The customer's identification is guaranteed by the bank issuing the BankID. As one of the leading tools for digital identification in Sweden, most services requiring online identification do support BankID, including government, municipality, bank and company actors. This also includes signing transactions and documents, with services ranging from online and mobile banking, to tax declaration and e-trading. As such, BankID is used both for identification as well as signing. Digital signatures made via BankID are legally binding (Zefferer & Teufl, 2015). While the introduction of a BankID system is an effective way of making identity theft immensely more difficult, there are naturally fraud attempts that seek to hack users' BankID. To this end, the implementation of the *Quick Response* code (or more famously, the "QR-code") has proven to be an efficient tool that has caused a 90% dip in the number of reported BankID fraud attempts (Dobos, 2019). Still, the success rate of implementing national e-identification systems as a part of an e-governance strategy is contingent on the ability of positioning it towards the customers. In this, studies have shown that it may be possible for some local governments' e-identity solution to become applicable on a national level, should one desire to ease the concept in gradually to a wider population (Tsap, Pappel, & Draheim, 2017).

For more general means of protection, virtual private networks (VPN) is a useful tool as a means of data-encryption software that hides the users' identity, online activity and communications from unwanted eyes. While it was historically used to ensure secure connections into corporate networks, it has nowadays found its use in many consumers' homes as people use them to secure their presence in cyberspace by cloaking their IP address from other users, making their activities invisible (Bixler & Schmied, 2004; Hassan & Hijazi, 2017). This also helps throw the scent off the user from any potential hackers or other nefarious online threats. Though it is advisable to exercise caution regardless, as some VPN services do not make a user untraceable, and users who employ those VPNs for communications may find themselves being anything but anonymous (Dordal, 2018).

3.3 Physical Protection

As per the United Nations, the public institutions of a nation should ensure that harm to the citizens is minimised and that they are granted inalienable rights such as "life, liberty and security of person" (United Nations General Assembly, 1948, sec. 3). Denizens evaluating physical security may ponder two aspects of their trust in their city. First, does the city possess the *capability* to keep the residents safe? Second, can the people trust the *intentions* of the city governance to protect its denizens? These assessments of a city's capacity and/or motivations are essential to the denizens' perceptions of a city's security, with ensuing consequences for private responses. Due to the rapid technological advancement, digital innovation has resulted in more efficient and widespread private efforts with the potential to disrupt the role traditionally held by the city's public sector (Conley & Nakkawita, 2020).

Historically, it has been incumbent on the authorities (be they city, regional, provincial, national or otherwise) to keep the denizens safe. Nevertheless, a new development started pushing its way throughout the twentieth century, where governments began collaborating with private entities for the intended betterment of citizen security (Bethune & Martin, 2003; Rabaiah & Vandijck, 2009). The reasons would vary, including anything from financial efficiency to technological superiority (Markusen, 2003). As technology continues to develop at a rapid pace, there are various impediments hampering the public sector's ability to keep up with the technological advancements. It is important to remember that the public sector procurement regulations exist with the intention of preventing fraud rather than to ensure quality services (OECD, 2016; Telgen, Harland, & Knight, 2007). This often means that procuring for the public sector is unwieldy, slow and costly, since one must account for highly specific requirements and legacy systems. The procurement status quo in many places also tends to favour the actors with the strongest lobbies (Baumgartner, Berry, Hojnacki, Kimball, & Leech, 2014; Baumgartner, Berry, Hojnacki, Leech, & Kimball, 2009; Nownes, 2006). Hence, the financial incentives for changing the status quo are suboptimal and the public sector is often unable to keep up with the faster moving environment of the private sector. To this end, the public sector often fails to be the frontrunner of the innovation agenda, resulting in the consumer market for innovative solutions superseding that of the public sector (Conley & Nakkawita, 2020; FitzGerald & Parziale, 2017).

In a technologically advancing landscape, denizens have already begun to seek out solutions presented by private actors aimed at heightening the security for the everyday man and woman. As the nature of crime is adaptable to the scenarios presented by pandemics, denizens will need new solutions to keep themselves as safe as possible, solutions made possible through the development of digital technology. As the public sector is unlikely to be the sole forerunners of employing such innovations, it is likely that we will see a trend that involves a larger role for private entities in ensuring people's protection (Comaroff & Comaroff, 2016; Conley & Nakkawita, 2020; Leander, 2005; Woolner, 2011).

For instance, digital technology has increased people's own protection capabilities, such home security systems (Electronic Security Association, 2019). The number of mobile- and WiFi-based home security options sold to private consumers expanded immensely during the COVID-19 pandemic (Butt et al., 2021; Walker, 2020). This also includes various mobile-based apps such as *Haven* (co-developed by famed American computer security whistle-blower and former CIA/NSA contractor Edward Snowden). The purpose of apps such as this is to monitor activity occurring in the proximity of a device using its built-in sensors, and to alert the device owner of any such activity taking place (Webb, 2020). As mentioned previously, home burglary is a crime that typically decreases during a pandemic when most are mandated to stay in their homes. Interestingly, the previously mentioned surge in popularity of digitalised home security systems suggests that consumers would rather trust the capabilities and intentions of actors promoting private security (Conley & Nakkawita, 2020). This suggests that there is a wider use for similar surveillance apps on the market, irrespective of whether it concerns a crime that has actually increased or decreased statistically, especially regarding property crime.

To this extent, security robots and drones developed by private corporations may play an important role combating crime in the future. According to some reports, robots will be patrolling cities by 2040 with their main tasks include ID checks, tasering and arresting suspects along with crowd control

(Puig-Pey, Bolea, Grau, & Casanovas, 2017). To minor degree, some of these solutions exist already today. So-called security robots are already patrolling parking lots and shopping centres in California, like dehumidifier-shaped mall cops. The California-based security camera company Knightscope specialises in producing and deploying "autonomous data machines (ADMs)", a type of autonomous robot, or "autobot" (Layton, 2020; Rada, 2019). In 2015, they released their K5 model, a 181 kg and 1.6 metre bullet-shaped robot described as a cross between "R2D2" from *Star Wars*, and a "Dalek" from *Doctor Who* (Knightscope, 2022b; Puig-Pey et al., 2017; Spilsbury & Spilsbury, 2017). Moving at a speed of approximately 5 km/h (3.1 miles/h) and using an assortment of sensors such as a video camera, thermal imaging sensors, a laser range finder, radar, air quality sensors and a detector for suspicious wireless signals, the autonomously charging K5 is able to detect crime by surveying abnormal noise and temperature change or known criminals (Spilsbury & Spilsbury, 2017). Clients are charged an hourly rate of between roughly US$4 and US$9 (depending on the model) per hour for each unit they use (Knightscope, 2022a). While the K5 is not able to arrest criminals or physically stop crime, it is able to notify law enforcement so that police or guards can be sent to the location.

The K5 model was chiefly developed for the purposes of patrolling malls, parking lots and neighbourhoods (Mishra, Goya, & Elngar, 2020). However, more advanced models capable of considerably faster speeds and more suitable for terrain use, such as the K7 model, are currently in development (Knightscope, 2022c; Orage Forlag, 2020). Of course, there are many other similar products abound as well. In many instances, the mere presence of such autobots may act as deterrents, following the concept presented by English

Image 9.1 The Knightscope K5 security robot patrolling a parking garage.
Source: Yngvadottir, Creative Commons.

philosopher Jeremy Bentham (1791) and his notion of "Panopticon". The premise behind his concept that an infrastructure or institution is designed in such a way that it allows for some denizens to be observed by a single security guard (or equivalent), without the people knowing which ones are actually being observed. The consequence is that the people act in a way that they assume they are observed (even when and if they are not in reality) and thereby act in a more law-abiding fashion. Though an important caveat that bears mention is that the flipside of this type of surveillance technology is that it could easily be used by totalitarian states to keep the denizens in the cities under control (Layton, 2020).

Beyond that, there are a number of other initiatives underway that aims to bringing the shootings down as well. These initiatives primarily concern technology that seeks to slash response times, thereby buying more time for civilians to seek cover and for the law enforcement to arrive on the scene to neutralise the perpetrator(s). One example of such an initiative is "ZeroEyes", a company that employs visual AI on to CCTV footage in order to detect when someone is carrying an unholstered weapon, and if so, alerting law enforcement (Andrejevic & Selwyn, 2020). CCTVs have been in use for a long time and their effectiveness on certain crime prevention are well-established, especially so in particular regard to car thefts in car parks, and if combined with other factors such as optimal street lightning and so forth (Piza, Welsh, Farrington, & Thomas, 2019; Welsh & Farrington, 2004). By making them "smart", it is possible to optimise their effectiveness even further and reduce the risk of mistakes caused by "dumb cameras" and the human factor, such as missing important details that may be difficult for the human eye to spot at a first glance. Naturally, deploying smart CCTVs in the public space must be done with the utmost caution and their deployment should be based on actual need rather than the smart technology's availability or cost (Surette, 2005).

Other crafty solutions to the shooting problem include introducing "smart guns" that can only be fired by authorised users through the use of an "integrated remote control" (Brennan, 2017). The principle behind this solution is that firearms would be equipped with some kind of transmitter, such as those radio transmitters found in cell phones, upon which they would be given a unique ID number and a timestamped data on each round it fires. The firearm safety could be controlled via an app, which would, in turn, transmit commands to ultra-lightweight levers in the stock of the firearm. In the event of a shooting, the law enforcement could be provided with a backdoor into the software after which one could check cell tower records in order to determine which specific firearm has been fired in the vicinity of the shooting. Not only would the police be able to quickly identify the gun, and possibly even the shooter, but they could also disable the gun remotely. Naturally, the caveat here is that this is likely to only stop a smaller number of incidents where the shooter is acting on impulse. Any criminal acting with a modicum of premeditation and/or awareness would most definitely not be using a gun with this type of technology integrated in it, or at least not without disabling it.

To this end, deploying drones and security robots in potentially hazardous situations where there are weapons involved could present itself as a viable alternative. An armed robot could target (and subsequently neutralise) a shooter using visual sensors and data gathered via a gunshot detection system, which is a system that is able to detect and convey the location of gunfire using acoustic, vibration, optical and/or other types of sensors (Carter, 2012). However, it is extremely challenging to develop such technology for use in close-range, crowded spaces, such as malls, schools, cinemas and churches/mosques/synagogues, etc., i.e. the typical places where a mass shooting would be most likely to occur. The system would have to discern between a panicked bystander from a gunman, which would require significantly more computing power than most robots have with current technology (Brennan, 2017). Also, it would require extensive legal reform in many places to allow autonomous systems to wield weapons, even if they are of the non-lethal variety. The current trend in most countries, states and cities is rather moving in the opposite direction, i.e., towards prohibiting armed, or weaponised drones, sometimes even by discussing the introduction of an international "anti-drone treaty" (Kreps, 2016, p. 41). However, some exceptions exist. In January 2015, North Dakota passed "House Bill No. 1328" (Legislative Assembly of North Dakota, 2015). This law made the North Dakota police force the first in the world to sanction the possibility of using weaponised drones, albeit with non-lethal weapons such as Tasers, pepper spray, and rubber bullets (Enemark, 2021; McGuire, 2021).

For crime in general, "predictive policing" may present an opportunity, though it should be noted that there is an ongoing debate whether or not digital technology is advanced enough for it to be put to widespread practical use (Alikhademi et al., 2022). Essentially, this term refers to a set of mathematical, predictive analytics as well as other analytical techniques in law enforcement used to identify potential criminal activity, often with the intended purpose of stopping crime before it happens (Brayne, 2021). While predictive policing should not be seen as a "crystal ball", it can help identify individuals and locations at increased risk of crime, and may be combined with other law enforcement techniques and strategies in order to make them more effective (Perry, McInnis, Price, Smith, & Hollywood, 2013). What predictive policing in effect does, is make use of data regarding the times, locations and nature of past crimes, in order to suggest where, and at what times, police patrols should be present. The purpose would be to make the most efficient use of resources and/or ensure the greatest likelihood of preventing crimes (McDaniel & Pease, 2021). A study from 20 city districts in Philadelphia showed that predictive policing led to a 31% reduction in expected crime count for property crimes and a 40% reduction in expected crime count overall across an eight hour time period (Ratcliffe et al., 2021). Nevertheless, it is important to emphasise that the effectiveness of predictive policing is contingent on sufficient input of useful data, as without it, predictive policing could actually result in negative and inaccurate outcomes such as policing the wrong areas at the wrong time, prospect of bias as well as being subject to apparent lack of operational transparency, etc. (Berk, 2021; Perry et al., 2013). Though it should be noted that some scholars view predictive policing with scepticism, with some expressing concerns of a potentially biased AI, while others argue that predictive policing disrupts police work, which may be counterproductive as it could lead to under-policing in certain areas (Akpinar, De-Arteaga, & Chouldechova, 2021). Another contention is that it would effectively prompt aspects of policing to be worked into urban planning policy (Lally, 2021; Tulumello & Iapaolo, 2022).

In regard to domestic abuse, digital technology is indeed a double-edged sword, as it may also be used to enable/empower abusers. While abusers have long used technology to spy on and harass their victims, the COVID-19 pandemic has given the abusers greater opportunities than ever before. As the victim is forced to remain at home with their abusive partner, it is much easier for the abuser to get hold of their partner's phone or laptop and alter their privacy settings, acquire their passwords or install tracking software on their devices. Abusive partners not living together in lockdown with their victims may feel an even greater need to keep their partner under surveillance (Bailey, Flynn, & Henry, 2021; Hodes, 2020). While certain features may be well-intended and much-appreciated by the average consumer, they can be put to cynical use by someone with malicious intent. For instance, a "smart doorbell app" that allows the customer to remotely see who is at the door, can alert the residents against burglars, vandals or otherwise unwanted visitors, even when they are not at home. However, it also follows that an abuser can use this functionality to be notified if ever their partner should leave the home. Also, various credit card apps exist that send notifications whenever a purchase is made, in order to help the customer keep better check against unlawful or fraudulent purchases made on their credit card. Still, this feature can also be used by an abuser to give him/her greater control over the victim's purchases (Nuttal, Evans, Franklin, & Burne James, 2019). At the same time, technology may also offer a lifeline to victims of domestic abuse, enabling them to access support services and information or to record evidence.

As such, the role of technology in domestic abuse is a challenging issue, and there is no simple solution to resolve the problem. Nevertheless, by making subtle decisions and balancing intended with unintended consequences, it is possible for developers to design technology in a way that it does not serve to enable the abuser. In the case of domestic abuse, it is therefore not so much a matter of designing new technology, but rather more about how new technology is designed. Some companies (most notably IBM) have tried to address this in a more outspokenly fashion by championing various principles and pre-emptive thinking that seeks to prevent digital technology from being used as a tool of domestic abuse (Wray, 2020). For instance, the ability to make actively informed decisions about their privacy settings is quintessential, but these settings may be overlooked by the user if the language used is too technical or otherwise alienating. Specifically, phrases such as "advanced settings" may, in some instances, intimidate certain, less tech-savvy users, which may cause them to select the default settings without checking what these settings actually entail.

As such, the settings option in various apps and digital services that are intended for a broader, and not necessarily tech-savvy, audience, will need to be simple to understand and easy to configure. Moreover, their presentation should be informative, but at the same time neutral and not phrased in a way that it tries to present one option as the overall "better" alternative in all given instances or in any similar way try to influence the user to pick a particular option above another.

Digital products and services also need to be transparent about whatever possible changes have been made and where in addition to informing the user whenever remote functionality is triggered, making it difficult for the abuser to furtively survey their partner's online activity remotely. A local override for remote activation should also be provided wherever necessary, to allow the user to retain control of their services and foil any possible intrusions from an abusive partner. Finally, digital products and services intended for a more general audience should be designed to be as intuitive and user-friendly as possible in order to help reduce dependency on an abuser with perhaps greater technical confidence who may use their know-how to either install malicious software to spy on their victims, or as blackmail/leverage against them to make the victim do their abuser's bidding in exchange for their "help". The combination of user-friendliness and a feedback loop every time there is unusual activity on the device, is extremely valuable as it can help provide victims with a sense of reassurance needed to make them not feel that they are being controlled by the digital technology in question, but rather that they can use it to empower themselves (Nuttall, 2020).

Digital technology can offer other means of assistance as well to victims of domestic abuse, now and in the future. Already now, there are AI and NLP tools as well as wearable tech being developed to help predict trends, prevent domestic abuse and alerting law enforcement (Ates, 2021; Dave et al., 2021). Moreover, multiple safety apps and SMS-based services have been developed, and continue to be developed, that can educate users about domestic abuse with information about where to seek help if needed. Examples of a few such apps include "Kitestring" (2021), "Circulo" (2021), "Watch Over Me" (2015), "Safetipin" (2021) and "Saahas" (2020). In addition digital technology has helped to bridge various gaps in data, documentation, reporting and policy, while also providing faster, more efficient tools for victims during the lockdown (Ates, 2021). For instance, following the COVID-19 pandemic, King County, Washington, introduced an option for people seeking emergency protection against a domestic abuser to petition for a "Civil Protection Order" electronically rather than having to visit the courts in person (Radil, 2020).

4 Conclusion

The aim of this chapter was to explore how physical and digital security can be safeguarded in a smart city and how it can be used to strengthen resilience. Based on the findings, the following action points are suggested for ensuring pandemic resilience.

Action 1: Open up for the Possibility of Public–Private Partnerships in Areas Where the Public Actors Cannot Keep Up

While denizens may doubt the government's ability to adequately protect its people, most denizens still believe that the government should play a major role in protecting its citizens (Conley & Nakkawita, 2020). On the face of it, this would create a narrative dissonance regarding whether or not the government should have a more active role in providing security to the citizens or if it would be better to outsource this task to private contractors. However, the fact of the matter is that the governing bodies do provide the denizens with a sense of legitimacy and there appears to be a genuine desire among citizens to see the government succeed in keeping the citizens safe. This suggests that the time may be ripe for more frequent and extensive public–private partnerships in which private actors could operate under the auspices/authorisation of the government in providing various digital solutions to its denizens, and possibly even develop a reporting system that is compatible with that used by local authorities. We have already now seen areas in which private companies have been able to develop apps and other forms of digitally automated surveillance tools that can help alert law enforcement of suspected criminal activity. However, the government's involvement should act as a guarantee that laws are upheld and that only pertinent data is collected and in that way ensures that the social contract is upheld. Moreover, there needs to be full transparency in the procurement and operations in order to ensure legitimacy and there needs to be a nonpartisan agency or body that oversees any such collaborations/partnerships in order to safeguard that data is used purposefully and accurately.

Action 2: Develop Autobots to Assist Law Enforcement in Problematic Areas

Autonomous robots can help take the pressure of the police and security guards for more menial surveillance tasks, and may as such provide a more effective alternative to CCTVs in certain instances (or at least help act as a supplement), or in some cases, just act as deterrents. Again, the deployment and utilisation of autobots need to be subject to continuous review by the authorities, under an objective, independent agency or governing body. It is also essential that autobots are developed and perfected so that they act on data that is accurate and adequate. On this note, it must be emphasised that autobots should be there as tools to assist law enforcement and never as a means to substitute or disrupt "human" police work or guard duties. Nor should the presence of autobots ever be allowed to be used as a pretext to under-police areas in need.

Action 3: Develop Natural Language Processing (NLP) to Counteract Fraud

NLP has proven to be efficient in detecting various online scamming attempts. While it is showing great promise, the technology is currently still lacking and is in need of being perfected further. More support is therefore needed to those scientists working towards refining and improving the algorithms.

Action 4: Improve Multi-factor Authentication

Identity theft is a serious problem that has grown significantly in the digital era. Thus, more efficient means of encryption and multi-factor authentication is needed, while at the same time not making the process too cumbersome for the user. BankID has proven to be a popular and effective solution devised in Sweden, and similar solutions may prove as fruitful even for other countries.

Action 5: Increased Support to Victims of Domestic Abuse

The COVID-19 pandemic has markedly worsened the condition for many of the victims of domestic abuse. In many ways, these people have been overlooked by society in the turmoil brought forth by pandemic, even though many, relatively simple courses of action could do much to alleviate their situation. One measure would be to enable an option for people seeking emergency protection against a domestic abuser to petition for such an order online rather than having to visit the court building, as this may make it easier for them to follow through with this step. Another possible measure is to develop and perfect various apps and weartech etc. to assist victims at risk of being contacted by an abusive partner, and also to spread information of and accessibility to such solutions.

Concluding Remarks

Keeping denizens safe in a city and having the people trust in the authorities' ability to do so is essential for ensuring that the social contract is upheld. In many aspects, this is a team effort with the national and sometimes even regional authorities, especially in regard to allocating funds and setting new overarching political strategies. Nevertheless, the city's ability to uphold law and order is quintessential and by taking initiatives and initialising projects, cities can also become pioneering role models for other cities to follow suit, and ultimately even set a good example for other countries to be inspired by too. Cities able to produce successful outcomes present a great lobbying power over national and regional governments, which may, in turn, increase the prospects of them being able to allocate additional funds and resources in enhancing the security for its denizens. It is important to acknowledge that the nature of crime changes in the face of pandemics, and it is important to be prepared to revise extant criminological "truisms" on which the contemporary law enforcement mechanisms rests upon. In doing so, the cities may lead the way and devise new, sustainable, strategies for application under pandemics.

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10 Sustainability

Ensuring Urban Sustainability for Smart Cities during and after Pandemics

1 Introduction

"Sustainability" seeks to reconcile the inherent dichotomy between the rapid pace of urban transformation and the slow pace of environmental resource renewal. Pandemics and crises will invariably expose the shortcomings of the incumbent economic system and practices, while highlighting the challenges of securing sustainability (Abastante, Lami, & Gaballo, 2021; Low & Smart, 2020). The shockwaves spread by a pandemic will lead to the invariable question of whether or not society can ever again go back to that which was, and in the same manner as before.

When the COVID-19 pandemic struck in 2020, it did not only challenge the resilience of cities, it also exposed the scarcity of our resources, the fragility of our supply lines and the tension among international relations. Pandemics beget emergencies, which, in turn, accentuate the transformational needs that call for a greater degree of responsive and agile planning. This is contrasted by traditional urban planning, which necessitates defining long-term growth targets and defining the conditions for these in terms of potential land-use needs (Kakderi, Oikonomaki, & Papadaki, 2021). However, pandemics and its ensuing crisis disrupt the urban environment. Hence, the urge for transforming urban structures stretches beyond merely the physical spaces, such as the use of land, infrastructure, buildings and so forth, since there is also a need for reforming approaches and procedures as well.

Paradoxically, global pandemics such as COVID-19 also present societies with an opportunity to build up a long-term resilience by exposing the chinks in the armour and ensuring that they are rectified. However, this can only be achieved by taking decisive action that not only focusses on safeguarding national economies during an actual pandemic, but also ensures that the society is sustainable at any given time (Abastante et al., 2021). The notion of resilient urban planning sets the tone of a new type of planning that seeks to account for both the need to expedite changes that facilitate societal recovery as well as the complexity of urban ecosystems and their various interrelations and systemic interactions (Kakderi et al., 2021; Tobin, 1999).

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A buzzword that is so often recurring in this day and age is "sustainability". However, the term "sustainability" in and of itself remains a much debated and ambiguous concept. At bedrock, "sustainability" may be defined as a "diverse, interdisciplinary field focused on identifying how human culture and all living systems of the biosphere can endure and thrive into the long-term future" (Robertson, 2017, p. ix).

Urban centres around the world were severely impacted by the 2020 eruption of the COVID-19 pandemic. The ensuing confinement and social distancing entailed a radical change to people's lifestyle, while also exposing many weaknesses inherent in society (Sharifi & Khavarian-Garmsir, 2020). On the one hand, the pandemic raised questions regarding the importance of key elements in our environment that contribute to our health and well-being, e.g. the quality of air, the availability of open and green spaces etc. (OECD, 2021). On the other hand, the pandemic called into question many established "truisms" and dominant practices that have been evolving throughout the past few decades (as will be elucidated upon throughout this chapter) (Veltmeyer & Lau, 2021).

The pandemic response, and the new set of societal rules it dictated, placed a particularly great strain on urban planning. Most notably, urban planning was now tasked with creating a balance to ensure growth. On the one hand, with concentration of talent and the social interaction that an urban dwelling entails, and on the other hand, curbing the spread of disease by creating social and societal restrictions of various kinds. The pandemic response, to a greater or a lesser extent, established a new precedent in what the "norm" would be during and following a pandemic. Fundamentally, it would serve to alter the perception and behaviour of people, particularly in urban settings. Arguably, cities' level of responsiveness and their pandemic resilience is to a large degree affected by technology. That is to say, technology in smart cities can be utilised to convey and operationalise complexities in a manageable way, enhance the city's responsiveness, while also creating spaces for denizens to socialise and co-create in new ways (Baron, 2012; Pilipiszyn & Hedjazi, 2018).

Smart cities carry the advantage of possessing well-advanced digital technologies that can help improve the readiness, capacity and operability of various urban environments and for various situations. By extension, this may lead to a more informed decision-making process by the authorities, as well as more favourable outcomes for the denizens (Deal, Pan, Pallathucheril, & Fulton, 2017; Kakderi et al., 2021). Digital technology also has the advantage of providing platforms that can enable social interaction and work-related tasks to be performed remotely (Komninos & Panori, 2019). This has been a determining factor in many regards in keeping societies at least somewhat operational in times of pandemics, as evidenced by the COVID-19 pandemic when social distancing upended society's conventions and common practices.

Much like the other topics explored in this volume, the concept of "sustainability" is an essential factor in building resilience. Prior studies have illustrated that resilience in this regard is to a large extent contingent on national protectionist policies; however, these policies also tend to incur vulnerabilities towards ongoing crises/pandemics (Kakderi & Tasopoulou, 2017). However, rarely are any two crises identical. The challenges they bring forth, and the solutions to which, will often differ immensely between cases, along with the need to reassess and reconfigure the success of the employed techniques and technologies as they occur. While national policies are prerequisites and will often enable many options, they may, at times, only offer blunt instruments to remedy the problem at hand, with little regard to specific conditions or possibilities at a given place (Craswell & Weller, 1995; Kresl, 2007). To this extent, it will be incumbent on the future smart cities, with their technological advantages, to strengthen up as much as possible that which falls through the cracks set by national policy.

Nevertheless, "sustainability" as a concept carries many different connotations for several different contexts. In general, it concerns finding some form of optimal balance between all things social, environmental/ecological and financial, such as the "triple bottom line" and other similar approaches (Singh, Murty, Gupta, & Dikshit, 2012). More notably, the framework concerning "sustainability" in much of the contemporary popular discourse is often based on the 17 "Sustainable Development Goals (SDGs)". These were initially identified by United Nations' *2005 World Summit on Social Development* under what was initially called "Millennium Development Goals (MDGs)" (United Nations, 2019b; World Health Organization, 2015).

The 17 SDG areas are: (1) *No Poverty*, (2) *Zero Hunger*, (3) *Good Health and Well-being*, (4) *Quality Education*, (5) *Gender Equality*, (6) *Clean Water and Sanitation*, (7) *Affordable and Clean Energy*, (8) *Decent Work and Economic Growth*, (9) *Industry, Innovation and Infrastructure*, (10) *Reducing Inequality*, (11) *Sustainable Cities and Communities*, (12) *Responsible Consumption and Production*, (13) *Climate Action*, (14) *Life Below Water*, (15) *Life On Land*, (16) *Peace, Justice, and Strong Institutions*, (17) *Partnerships for the Goals* (Katila et al., 2020; United Nations General Assembly, 2015).

SDG 11: *Sustainable Cities and Communities* will be the point of departure for this chapter, as the remaining SDG lie beyond the scope for the purposes of this study. Though some scholars argue that there will invariably be some trade-off involved, a chief contention of the 17 SDGs is that action in any one of the SDGs will affect the outcome in other SDGs as well, and therefore achieving sustainability in this area will positively impact the procurement of the SDGs on a whole (Kaushik, Attri, Kaushik, & Schnell, 2021; Weitz, Carlsen, Nilsson, & Skånberg, 2018). Hence, this chapter will aim to explore how technology and policies can be applied to help smart cities achieve sustainability and pandemic resilience in accordance with SDG 11.

2 Sustainable Development Goal 11

The central tenet of SDG 11: *Sustainable Cities and Communities* is that it is seeks to "make cities inclusive, safe, resilient and sustainable" (Al-Zu'bi &

Radovic, 2019, p. 37). Building cities that are resilient to different kinds of disasters are a key determinant in ensuring SDG 11 (Smart, Haigh, & Amaratunga, 2021). However, while many cities will focus their sustainability efforts towards areas pertaining to basic services such as housing and transport, many lose sight of other areas such as ensuring the protection of cultural and/or natural heritage among many other factors (Devisscher et al., 2020). As such, it is essential to adopt a wider view of "sustainability" and acknowledge its pertinence in other societal areas as well.

SDG 11 communicates that there are seven identified "outcome" targets that need to be achieved in order to ensure sustainability for cities by the year 2030 (Brown, 2020; UNESCO, 2019). In addition, there are also three "means of achieving" targets that outline more overarching policy attitudes to help countries attain the aforementioned "outcomes" (UNESCO, 2019).[1] The underpinnings of SDG 11 are that it can provide the proper tool and framework to ensure guidance and improvement in its designated areas (Klopp & Petretta, 2017; MacDonald, Clarke, Huang, Roseland, & Seitanidi, 2018). As such, the "outcome" targets are: (1) *safe and affordable housing*, (2) *affordable and sustainable transport systems*; (3) *inclusive and sustainable urbanisation*; (4) *protect the world's cultural and natural heritage*; (5) *reduce the adverse effects of natural disasters*; (6) *reduce the environmental impacts of cities*; and (7) *provide access to safe and inclusive green and public spaces*.

This chapter will seek to utilise these targets as talking points for different sustainability areas in which technology may be used to build pandemic resilience while facilitating urban sustainability. The issues concerning the aforementioned targets 1–3 and 7 are largely covered in elsewhere in this volume, and will thus be excluded from further discussion in this chapter.[2] The premises of the remaining targets are described below.

Protect the world's cultural and natural heritage – The United Nations General Assembly (2015, p. 22) defines this as follows: "Strengthen efforts to protect and safeguard the world's cultural and natural heritage". This target intends to look at the total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by the type of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional and local/municipal) (UNESCO, 2019).

Reduce the adverse effects of natural disasters – According to the definition of the United Nations General Assembly (2015, p. 22), this target seeks to:

> [S]ignificantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.

This target focusses on efforts to (1) accurately report the mortality rates of internally displaced persons, missing persons and total numbers affected by natural disasters; and (2) account for the direct economic losses in relation to global gross domestic product (GDP), damage to critical infrastructure and the number of disruptions to basic services, attributed to disasters (Doni, Gasperini, & Soares, 2020).

Reduce the environmental impacts of cities – As per the United Nations General Assembly (2015, p. 22), this target seeks to: "Reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management". Particularly, this target aims to look at the (1) proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, and the (2) annual mean levels of fine particulate matter in cities (population weighted) (De Sherbinin et al., 2021; UNESCO, 2019).

3 Protect the World's Cultural and Natural Heritage

3.1 Survival of Culture

During the COVID-19 pandemic, most tourist attractions, museums, art galleries and so forth were effectively shut down in many cities across the world (R. Comunian & England, 2020; Jeannotte, 2021; Mak, Fluharty, & Fancourt, 2021). For all intents and purposes, the pandemic deprived the denizens from access to culture, both in their own countries and cities as well as that in others. This, in turn, would, in certain places, prompt fundamental changes in how we consume culture.

Throughout history, pandemics have had profound impact on culture (Vrdoljak & Bauer, 2020). The silver lining is that once a pandemic/epidemic has subsided, it often steers the denizens of a city and/or country, as well as political practices, towards an increased cultural awareness (Kamsaris, 2017). Notwithstanding, cultural sustainability needs to extend beyond a logic that would merely adopt the apothegm of "survival of the fittest", such as that depicted by "Schumpeter's Gale", in which "untenable" forms of cultural expressions would be wiped out and replaced with more "robust" expressions (Schumpeter, 1943). Does this mean that all forms of cultural activities should be rescued at any given time at any given cost with the use of public funding if necessary? Most certainly not. In many cases, a force majeure (such as a pandemic) is merely the one to deliver the "coup de grace" to an endeavour that has been declining for an extended period of time. Nevertheless, the main problem, as far as cities go, is that in a shifting economy, a "destructive" phase can last a long time due to geographic immobilities (Bertola & Ichino, 1995; Geroski & Gregg, 1993). Particularly so in an area such as culture, of which many aspects are often geographically conditioned in one way or another (Hewitt, 1996; Mohanty, 2005; Winner, 1979). Cultural expressions are also in many cases inherently niched towards a specific area and rarely consist of fully substitutable goods (Robinson & Novelli, 2005). Hence, large-scale closure and job loss tends to be particularly tough on the cultural sector. Although new jobs may be generated in the economy as such, these are not exclusively generated in the cultural sector and people active in one particular area of cultural work will not necessarily be able to perform the same kind of work in a different type of culture. This, in turn, can lead to not only a prolonged period of low growth and high levels of unemployment in the city, but also to the city's cultural decay (Kyridis, Korres, Tourtouras, Fotopoulos, & Zagkos, 2020; Willoughby, 1990).

A 2020 OECD report confirmed that, along with the tourism sector, the cultural and creative sectors (CCS) were among those most affected by the COVID-19 pandemic, with jobs at risk ranging from 0.8% to 5.5% of employment across the OECD regions (Travkina & Sacco, 2020). In this, the CCS include all sectors whose activities are based on cultural values and/or artistic and other creative expressions, including, but not limited, to concepts such as architecture, archives, libraries and museums, artistic crafts, audiovisual (e.g. music, films and electronic entertainment), tangible and intangible cultural heritage, design, festivals, literature, performing arts, publishing and fashion etc. (European Commission, 2018; Travkina & Sacco, 2020).

The following cities stand out in particular: Seoul, South Korea; Oslo and Akershus, Norway; and Île-de-France, France, since these cities had the highest share of CCS employees among OECD regions overall, and were thus particularly susceptible to pandemic impact on the CCS sector (Travkina & Sacco, 2020). On a more overarching level, a weakened cultural sector might further be challenged by long-lasting gathering restrictions, which effectively eliminates many of the platforms in which communities could approach and engage with culture (Iftekhar et al., 2021). This, in turn, stresses the urgency of finding technological means to help make culture sustainable.

3.2 Culture during Lockdown

It is true that some specific types of cultural activities experienced a surge during the COVID-19 pandemic. It has, for instance, been reported that the video on demand service company Netflix acquired a record number of subscribers during the COVID-19 lockdowns, going from 167 million subscribers worldwide in 2019, to roughly 203 million subscribers in 2021 (Padgett & Loos, 2022). However, these would be the exceptions, as the pandemic had overwhelmingly negative impact on the accessibility to cultural activities overall (Travkina & Sacco, 2020; UNESCO, 2020). Also, it should be added that Netflix, in particular, would later see a considerable subscriber loss during the spring of 2022, equalling more than a US$50 billion loss (or a 39% share drop) for a number of purported different reasons, including an increasing inflation (making customers more prone to cut costs by terminating the service), password sharing among family members and friends, and Netflix's exit from the Russian market following the 2022 Russian invasion of Ukraine (Patnaik, 2022; Thomas, 2022).

While pandemics and lockdowns by and large have detrimental effects on culture, research has shown that those who engage in the arts during lockdowns are in many cases the same people who would have otherwise been engaged even if there had not been a pandemic present (Mak et al., 2021). However, in the case of the COVID-19, the pandemic would create new incentives and opportunities for people to engage digitally/virtually and in many cases it even acted as a coping tool for people to endure the hardships of the pandemic (Celinscak & Hutt, 2021; Mak et al., 2021). Indubitably, lockdowns place restrictions on the types of art with which it is possible to engage. However, four types of home-based arts engagement have been possible, which include: (1) digital arts and writing, (2) musical activities, (3) crafts and (4) reading for pleasure (Mak et al., 2021). During COVID-19, many activities were moved online, such as concerts, art events, conventions and festivals. However, a sizeable problem is that roughly half of the world's population lacks functional Internet access, and are thus unable to partake of such alternative means of conveying culture (Del Portillo, Eiskowitz, Crawley, & Cameron, 2021; United Nations, 2020).

As a countermeasure to the general negative impacts on cultural practices caused by the pandemic, UNESCO (2020) suggested that authorities should take three key steps, namely: (1) direct support to artists and cultural professionals, (2) indirect support to cultural and creative industries, and (3) strengthening the competitiveness of cultural and creative industries. In concrete terms, this entails, among other things, the commissioning and purchase of works; providing compensation for the loss of income; promoting programmes aimed at developing new skills; providing temporary relief from tax and social charges; promoting national content; stimulating demand; and enabling preferential loans.

3.3 How Cities Can Help Make Culture Sustainable

UNESCO (2020) contended that in order for culture to survive during times of COVID-19, there would be a need to secure the artists' salaries, since the remuneration they receive from copyright/royalties is generally untenable in and of itself. UNESCO argued that the national governments would need to do more in order to set up various forms of relief funds or temporary aid systems for these artists in financial need. However, public funding for the arts had already begun diminishing since the 1980s, and private funding for the arts inherently reward artists who are already established and successful (Moss, 2017). Setting up a national relief fund is associated with many pitfalls. For instance, proper social protections would need to be adapted to address the conditions/circumstances of the creators. Also, in order to ensure transparency and objectivity, there would need to be clear and transparent eligibility criteria that target those aspiring to make the practice of art their main source of revenue. Even with such factors in place, artistic expressions are difficult to measure, and in some cases there is a clear bond/association to a particular geographic setting/culture. Sometimes, an artful expression is just as important and valuable to the denizens of a particular city as another one can be to people on a broader, regional, national or even international scale. Given the limited funds available, the practice by those issuing the funds to seek the greatest good for the greatest number, may cause more niched/local artists to fall by the wayside.

In this regard, cities could play a crucial role. For instance, in 2021, New York City announced that it would launch a new programme called "City Artist Corps", to provide funding to artists for public works in an effort to extend financial support to artists whose income plunged during the COVID-19 pandemic (Gold, 2021; Zucker, 2022). New York City Department of Cultural Affairs pledged a total of US$25 million to the program, where it would distribute US$5,000 one-time grants to artists across the five boroughs to produce free, live and in-person programming (Wright, 2022). The programme would generate some 3,000 artist-led public engagements across the city (NYC Cultural Affairs, 2021).

Also, companies that were able to weather the storm (or possibly even grew as a result of the pandemic) could be incentivised by the city authorities to launch joint initiatives, production support and/or dedicated programs for independent artists or smaller artistic content creator studios. French economist Yann Moulier-Boutang (2011) referred to what he called "cognitive capitalism", a contention that work in the contemporary economy depends more on ideas, knowledge, skills and aptitudes that are, for lack of a better word, "cognitive" or "intellectual", and less so on labour that is physical, corporeal or manual. In this way, knowledge and skill becomes a "mode of production". Proverbs 27:17 teaches us that "iron sharpens iron". Similarly, Alfred Marshall (1890) promulgated notions of "agglomeration", or perhaps even an intellectual type of "contagion", where he argued that the availability and proximity of skilled workers would allow for the transfer of information, knowledge and skill (Chen, 2017).

In this manner, cities and digital technology hold massive potential to nurture the cultural activities that haemorrhage as a result of a pandemic. That is to say, the collective expertise from those CCS workers who are more resilient could support or facilitate digital transformation initiatives for those that have not previously relied on digital outreach. This includes the development of tailor-made, but scalable immersive experiences that would allow audiences to engage with the CCS workers' content in a "digital first", or even a hybrid digital-offline context (Dubois, Gauntlett, & Pringle, 2021; Gandini, 2016). Over-the-top (OTT) service in combination with sophisticated virtual reality (VR) and/or augmented reality (AR) solutions and future generations of broadband cellular network technology (e.g. 6G and beyond) could be future technologies to help facilitate this engagement. Furthermore, investments in infrastructure and communicative tools would be needed in order to redesign venues so that they become more attuned to and accessible during pandemics, making them safer to visit. This will be useful even after the pandemic has subsided, because there will be a lingering social stigma and residual fears regarding mass gatherings, which will require massive means of communication and trust to overcome. For this reason, having the facilities and infrastructural adjustments in place should help mitigate this stigma to some extent as it lessens in time among the city denizens.

During the COVID-19 pandemic, universities remained largely operational much in thanks to their propensity to acclimatise their mode of teaching in a way that was possible during social distancing, such as introducing virtual classrooms etc. (Rennert, Kalbaugh, McMahan, Shi, & Colenda, 2021; Witze, 2020). The universities in various cities also play an important role inasmuch that university-based incubators "can provide a sheltered learning environment for those wishing to develop business ideas without incurring a large financial burden" (Jones, Meckel, & Taylor, 2021, p. 367). There is research to indicate that business incubators are key mechanisms to make entrepreneurship, growth and economic development more sustainable in society, even during pandemics such as COVID-19 (Lin-Lian, De-Pablos-Heredero, & Montes-Botella, 2021). Given that many universities possess the competency and capability for fostering entrepreneurship, some of these could become hubs for procuring space and support for various CCS endeavours in addition to being a place to offer various reskilling programmes and research initiatives to help build resilience among CCS workers (Dubois et al., 2021; OECD, 2020; Taylor, Green, & Hassan, 2021).

4 Reduce the Adverse Effects of Natural Disasters

4.1 Natural Disasters during a Pandemic

Sadly, natural disasters are inevitable and will always affect some cities more than others. New Orleans' "Hurricane Katrina" in 2005, and the massive earthquake outside Port-au-Prince in 2010 are but two prominent examples in modern time (Bell, 2013; Fradin & Fradin, 2010). Whenever a natural disaster occurs, it incurs distress on the city as well as the national resources, and, of course, the affected denizens. Catastrophes have the power to hurl societal development in any given city back several years, even decades, by annihilating lives, infrastructure and morale. At the same time, developmental factors, such as infrastructure built in exposed places to the forces of nature, does little to alleviate the problem. To this end, sustainable development and disaster risk reduction are intrinsically intertwined (Uitto & Shaw, 2016).

What were to happen in the case of a "double whammy", i.e. if a natural disaster strikes during a pandemic? This is what happened in the Croatian capital, Zagreb, on March 22, 2020 and the Croatian town of Petrinja on December 29, 2020 as they were each struck with a massive earthquake of magnitude M5.5 and M6.2 respectively on the Richter magnitude scale (Markušić et al., 2020, 2021). The lattermost reportedly destroyed half the town (Herak, 2021). These disasters exposed several urban and strategic weaknesses. That is to say, there was little to any preparedness from the city/town officials for an event like this to happen since several buildings had, and continue to have, low seismic resistance with approximately one third of all buildings being built prior to 1963, when residential and public buildings were chiefly built as masonry (Galić, Andrić, Stepinac, & Vukić, 2021).

Of course, the COVID-19 pandemic worsened the effect of the disasters considerably. A problem that surfaced was that Croatia's recovery strategy (much like many other countries) focussed extensively on preserving jobs and maintaining companies' liquidity rather than securing the means to reroute resources to rebuild after disasters, which, in turn, resulted in massive delays in initialising the reconstruction of the cities (Barić, 2021). Worse still, was the massive damage caused to hospitals and care facilities that were needed to treat COVID-19 patients (Atalić, Uroš, Šavor Novak, Demšić, & Nastev, 2021). To this end, the hospital in Petrinja, along with the primary health-care centre, had to evacuate its patients due to the extensive damage caused to those buildings (Herak, 2021). Patients suffering from COVID-19, along with the rest of the patients, were moved to care facilities in Zagreb and Karlovac, while long-term patients were moved to military barracks away from the city (Miranda et al., 2021). The earthquakes furthermore heightened the risk of accelerating the pandemic as it became increasingly more difficult to observe social distancing, with shelters and homes being particularly exposed (Herak, 2021). The disaster also caused the Croatian government to suspend the intercountry lockdown, which had imposed restrictions on travelling in and out of the country (Thomas, 2020).

Naturally, various other acts of God during the COVID-19 pandemic occurred in many other cities as well. For instance, a small but deadly tornado struck Tennessee, primarily affecting Nashville and Mount Juliet, on March 2–3, 2020, leaving 25 people dead and 309 people injured (Kijewski-Correa, Roueche, Mosalam, Prevatt, & Robertson, 2021). To make matters worse, the number of COVID-19 infected began to escalate, affecting relief efforts. For example, Community Resource Center (CRC) of Tennessee, a Nashville-based non-profit aimed at collecting and distributing goods during emergencies, normally sees its volunteer crew number in the hundreds, but it dwindled to around ten following the pandemic, severely impacting their ability to assist in the natural disaster (Wei-Haas, 2020).

In Japan, the main island of Kyushu experienced massive floods July, 2020, causing more than 50 casualties (Suppasri et al., 2021). However, with the pandemic, the damages from the disaster were not the only distressing factor. Just prior to the floods on July 1, 2020, the number of reported COVID-19 cases was 99, whereas a fortnight into the flood, on July 21, 2020, this number had climbed to 502 cases to later skyrocket to a whopping 1,434 cases on August 7, 2020 (Ezzat, Abdelghafar, & Hassanien, 2021). Additionally, in 2021, there were numerous large wildfires spreading across several continents, with the ensuing smoke becoming an added risk factor to exacerbating the COVID-19 pandemic (Kiser, Elhanan, Metcalf, Schnieder, & Grzymski, 2021; R. Tang et al., 2021).

4.2 Technology's Ability to Mitigate Disasters

The lingering question is how technology can improve the situation? Granted, natural disasters are bound to occur at various places both during and outside times of pandemics. In order to ensure preparedness, one has to implement flexible systems that are not merely activated in case of disaster itself, but rather those that can account for multiple hazards occurring concurrently. In this, the digital twin cities can provide an essential tool to helping the cities pre-emptively build up resilience. For a more extensive discussion on digital twin cities, please refer to Chapter 8: *Digitalisation*.

In short, a digital twin city would, in this context, be able to create a digital replica of an entire city in order to allow experts to conduct real-time resilience testing to estimate how the city's infrastructure will perform in the face of various disasters (Zingariello, 2021). The crux is that such endeavours require massive amounts of data, meaning that in order to devise an optimal digital twin city, collaboration between different actors would be needed (Nagarajan, Anand, & Sakthivel, 2020; Yigitcanlar et al., 2020). This may sometimes be difficult to accomplish, but Newcastle University and the water services company, Northumbrian Water, is an example of two actors collaborating in this regard (Gilbert, James, Smith, Barr, & Morley, 2021). For some years, these actors have been working on developing a digital twin city aimed at providing Newcastle with a virtual representation to run computer-generated simulations of occurrences such as burst pipes, heavy rainfall or severe flooding etc. in order to illustrate the effects on people's homes and communities over a period of 24 hours (Augustine, 2020). While this particular digital twin city is not primarily geared towards assessing pandemics, it illustrates the potential in engaging different actors in order to devise digital twin cities to predict outcomes and expose weaknesses in the city. For instance, it may caution the authorities which areas are likely to be overwhelmed, which operations that will cease to function, which clinics that are prone to being the worst affected and so forth. In this regard, the Newcastle project was also used to collect evidence of the effects of measures introduced in response to COVID-19 in the cities and urban areas around the Tyne and Wear County in the UK (James, Das, Jalosinska, & Smith, 2020; Newcastle Urban Observatory, 2021).

While a digital twin city will not be able prevent disasters as such, it will provide the authorities and researchers with better information about what areas to fortify and what areas to keep added contingencies for in the event of a pandemic. However, the construction of a digital replica is a huge undertaking and will be reserved to the larger metropolitan areas to start with, where it will benefit the greatest number of people. In this regard, it will also necessitate the synergy effects of engaging multiple actors as well as the ongoing data collection for an extended period of time before the replica can be optimised.

5 Reduce the Environmental Impacts of Cities

5.1 The Urgency of Air Pollution

Reducing the environmental impact of the cities may seem like a Sisyphean task. Regardless, the issue is becoming ever more pressing as the urban population keeps expanding. Cities are major contributors to climate change. While accounting for less than 2% of the Earth's surface, they consume 60–80% of the Earth's natural resources and produce 50% of the global waste and 75% of the greenhouse gas emission, a figure that is expected to triple over the years leading up to 2030 (Andreucci & Croci, 2021). In fact, it is known that 25 megacities around the globe produce roughly 52% of the world's urban greenhouse gas emissions (Wei, Wu, & Chen, 2021). As cities grow, emissions will follow suit, at least on an aggregate level. To this end, it is imperative that urbanisation becomes a tool to combat global warming rather than adding to it, although this may entail reimagining "urbanisation" as we know it. That is to say, there are examples of cities that have been successful in decoupling growth from emission. One example of this is Stockholm, Sweden, which in 2019 contributed to more than 30% of Sweden's GDP, but only slightly more than 15% of the country's total greenhouse gas (Statistics Sweden, 2021).

Stressing the sense of urgency, it is anticipated that, each year on a global level, approximately 4.2 million people perish in pulmonary, cardiac and respiratory diseases caused by outdoor air pollution (Donzelli, Cioni, Cancellieri, Llopis-Morales, & Morales-Suárez-Varela, 2021; Gabrys, 2021). Beyond that, air pollution is also strongly linked to various medical conditions such as strokes, heart attacks, miscellaneous forms of cancer, dementia, premature birth and many other types of medical conditions (Gardiner, 2019). A common source of air pollution is fine particulate matter with a diameter of 2.5 microns or less ($PM_{2.5}$), which can penetrate deeply into the lung, irritate and corrode the alveolar wall, and consequently impair lung function (Xing, Xu, Shi, & Lian, 2016). These particles consist of dust, dirt, smoke, heavy metals and are roughly 1/30 the width of a strand of human hair (Dutt, Pomeroy, Islam, & Chatterjee, 2016). This means that regular surgical face masks are unlikely to offer adequate protection towards $PM_{2.5}$, since they are designed to stop liquid droplets and are generally looser fitting, leaving a gap between the edge of the cover and the bearer's skin for lightweight particulates to sneak through (Harrison & Daly, 2019). Rather, one would need, at least a particulate mask (also known as "$PM_{2.5}$ masks") or the N95 or K95 medical grade respirators, but these carry the added trade-off of inhalation resistance as opposed to a surgical face mask (Zhu, 2022). Higher-grade face masks/respirators are commonly worn in many smog-affected cities such as Peking

(Bejing) and Shanghai etc. (Balakumar, 2021; Gardner, 2018). The World Bank (2022) has reported that as of 2017, 99% of the world's population were living in places that exceeded the World Health Organization's (2021) air quality guidelines levels.

At various stages throughout the COVID-19 pandemic, media and popular discourse would frequently comment on the positive effects the lockdowns had on the environment in the form reduced emissions, with some even touting the pandemic as an "opportunity" to build smart and sustainable cities (Fatewar & Redhu, 2021). However, the truth of the matter is that while there is some reduction of $PM_{2.5}$ from the large emissions reduction in transportation and the slight emission reduction on the industrial side, lockdowns are not the answer to improving the environment (P. Wang, Chen, Zhu, Wang, & Zhang, 2020). This is because lockdowns will not undo air pollution and its effect is even more marginal when accounting for unfavourable weather conditions (Cai, Jiang, Chen, Jiang, & Wang, 2018; P. Wang et al., 2020). In fact, it is known that there is a positive correlation between air pollution and the spread of COVID-19 since particulate matter could create a suitable environment for transporting the virus at greater distances while also inducing inflammation in lung cells, thereby increasing the susceptibility and severity of the virus (Bourdrel, Annesi-Maesano, Alahmad, Maesano, & Bind, 2021; S. Comunian, Dongo, Milani, & Palestini, 2020; Wu, Nethery, Sabath, Braun, & Dominici, 2021). This is exemplified in the case of Manhattan, New York, where it was estimated that out of the 1,904 COVID-19-releated deaths reported as of April 4, 2020, 248 would most likely not have died had the particle levels averaged just one unit lower over the past two decades (Gardiner, 2020). Indeed, air pollution is anathema of pandemic resilience, and thus it is crucial to cushion the environmental impact left by cities. This chapter will discuss some possible future technological/strategic advancements that could help bring the air pollution levels down and thereby help secure resilience.

5.2 Air Purifiers

A solution directly aimed at combating the symptom of air pollution is the concept of large-scale air purifiers. The case of Dutch inventor Daan Roosegaarde's experimental outdoor air purifying tower installed in northeast Peking (Beijing), China in 2016, and the similar 2018 initiative in Xi'an, are discussed in more detail in Chapter 6: *Welfare and Healthcare* (Raveendranathan, 2019; Smedley, 2019). Nevertheless, the concept of air purifiers has been debated in many other cities as well. For instance, New Delhi, India used outdoor air purifiers in an attempt to clear up the air ahead of hosting the Commonwealth Games in 2010 (Chakravarty, 2011). In August 2021, a "smog tower" (as the air purifiers are sometimes referred to) was installed in New Delhi – a giant outdoor air purifier made out of 40 enormous fans to purify the air in a 1.036 square kilometre (0.4 square mile) radius (Loh, 2021; Stanaszek-Tomal, 2021).

The basic premise of an air purifier is that it "vacuums up" polluted air after which it filters out the harmful particles and subsequently expels air that has been "scrubbed" clean (Raveendranathan, 2019). The current concepts concerning giant air purifiers are mainly rooted in the understanding that these be essentially immobile devices fixed in a specific place (Nedjati, Yazdi, & Abbassi, 2022; Raveendranathan, 2019). Still, mobile air purifiers with more customisable size and coverage could be a future development in order to design and tweak the purifier so that it acts at optimal capacity within the polluted urban area (Nedjati et al., 2022). Regardless, further testing is needed in regard to their effectiveness as there is currently a dearth of studies in this particular area. However, some studies have disputed the concept behind air purifiers, contending that "vacuuming" out the pollution from the air is not possible and that "smog towers" are inherently "unscientific" (Gulia et al., 2022; Guttikunda & Jawahar, 2020, p. 2).

5.3 Circular Economy

A valuable lesson taught by the COVID-19 pandemic was how it exposed the weaknesses of our economic system. Some researchers will argue that the so-called linear economic model, which has for all intents and purposes been the dominant economic model since the first Industrial Revolution (ca. 1760–1830), is founded on the "take, make, waste" premise (Brydges, 2021, p. 1; Lacy & Rutqvist, 2015, p. 4). This means that production is designed to obtain a natural resource, turn it into a product that is ultimately destined to become waste as it has been designed to be used until the end of its lifecycle (Lacy, Long, & Spindler, 2020). Sometimes, products are even designed to become obsolete, leading to their premature replacement. This practice is known as "planned obsolescence" and is more commonly recurrent in consumer electronics, although it affects other industries as well (Guiltinan, 2009; K. Pope, 2017). This means that consumers are required to continuously spend money purchasing new products to replace the old, worn-out ones, and/or obtaining upgrades that could possibly be avoided had the product been designed differently. This cycle promulgates short product lifespan and suboptimal material use, ultimately resulting in the disposal of more products at a faster pace (Ritchie & Freed, 2021). Another resource strain is the manufacturing of single-use products, which serve to exacerbate the amount of waste shipped to the landfills at a great cost not only to the environment, but also to the economy. To exemplify, in 2021, New York City paid a total of roughly US$2.38 billion through the Department of Sanitation (DSNY) for urban sanitation (New York City Department of Sanitation, 2022; Ritchie & Freed, 2021).

To this end, circular economy (CE) was developed as a solution to the deficiencies of the linear model, while redirecting focus on building environmental and economic sustainability (Lacy et al., 2020). Unlike the linear model, CE seeks to extend products' lifespan, and in doing so, also help reduce the amount of waste and curb the use of new resources (Zheng, Chen, & Wang, 2021). An ambition of CE is to imitate nature's closed systems where all waste is transformed into valuable resources (Sauvé, Bernard, & Sloan, 2016; Van Ewijk & Stegemann, 2020). In other words, products would not be designed merely to achieve longer lifespans, but also as a means of procuring multiple life cycles (Larsson & Lindfred, 2020). This is accomplished through designing products so that they can be repaired easier, while also enabling/simplifying the possibility to disassemble, replace and recycle worn-out goods (Morseletto, 2020; Sauvé et al., 2016). When the products and/or material are used repeatedly, the value of products can be preserved longer (Larsson & Lindfred, 2020).

As such, CE entails the possibility of decoupling resource use from economic growth (Scheel, Aguiñaga, & Bello, 2020). However, this would necessitate overhauling/reforming the extant linear economic models in order to generate revenue streams. For instance, if a product's lifespan would permit a two-time use, the recycling process could be shortened by reducing waste while limiting the extraction of new resources in that the product could be used twice as much as the conventional "take, make, waste" products (Larsson & Lindfred, 2020). Though one may argue that CE may be of lower monetary value for companies and industries, it carries the benefit of value-increase for individual consumers as well as environmental benefits. For this reason, the current linear tradition is not compatible with a reuse–remake society (Jackson, 2017). That is not to say that there is no room for any single-use items. On the contrary, during the COVID-19 pandemic, single-use articles such as face masks, plastic gloves and other protective equipment were crucial for protecting the health and safety of people (Mawkhlieng & Majumdar, 2021). To this extent, there is a trade-off in regard to products that should not be reused, which is why certain linear elements of the economy will need to persevere throughout and in-between pandemics. In these instances, the future challenge will be to reduce the dependency of plastic and develop more eco-friendly and bio-based materials and solutions at an affordable price (Patrício Silva et al., 2020).

Worth mentioning is that the extant CE research is overrepresented by European-based researchers (Larsson, 2021). Indeed, the concept of CE has been promulgated not only by the European Union but also by several national governments and multiple business organisations around the world (Korhonen, Honkasalo, & Seppälä, 2018; Larsson & Lindfred, 2020). However, while it is true that CE has been given more attention in business and politics in recent years, the general worldwide familiarity with the concept remains relatively modest. During the onset of the COVID-19 pandemic, there was a global circularity of a mere 8.6%, a number that has been declining in the past few years due to increased extraction, build-up of material stocks, along with low levels of end-of-use processing and cycling (Larsson, 2021; Van den Berghe, Bucci Ancapi, & van Bueren, 2020).

A problem with CE is that it is not easily defined on an overarching level. True, the general principle regarding reuse of material, saving natural resources and increasing product's durability etc. remains consistent, but beyond that, much of the literature remains eclectic in regard to what CE should encompass and what it should aim to achieve, or even how far it should go (Geissdoerfer, Savaget, Bocken, & Hultink, 2017). In many ways, CE has been compared to a "sixteenth century map", meaning that it navigates with a blurred worldview and that it is not always intended to provide an exact account of the complete economic benefits, but should rather serve as a representation that seeks to be as accurate as possible based on the current knowledge (Kovacic, Strand, & Völker, 2020). Much in the same way as the old maps did, which would often include illustrations of sea monsters, dragons and unicorns etc. in the "parts unknown" areas to illustrate the ideas, speculations and apprehension reflected in the cartographer and society at large (France, 2019; Van Duzer, 2013).

The dominant manner of conducting business is still the aforementioned "linear model" (dubbed by its critics as the "take, make, waste"-model), meaning that most procedures, standards and business models are adapted to accommodate for that setting (Larsson & Lindfred, 2020). However, the nature of CE is inherently disruptive, which means that in order for its full implementation, it would require a complete overhaul/reform of the economic system, including changes made towards attitudes, towards consumption, production and lifestyles. Still, not all areas are necessarily suitable to transform from the get-go, or if at all. For instance, many proponents of CE promulgate the introduction of a "rental economy", in which most products are rented and few are actually owned (Rathinamoorthy, 2019). While this works well for certain items, such as for OTT media services like Netflix, as opposed to buying and owning a physical copy on an optical medium (e.g. Blu-ray), some people may be more loathed towards renting all of their clothes, save for the types that are rarely worn e.g. bridal or festive attire. In this event, one would have to consider a mixed model, where it would still be possible to purchase and own products but where society makes an effort to recycle and up-scale products (i.e. where recycling increases a product's value rather than depreciate it). In this way, CE should be regarded in the same way as the sixteenth century maps, inasmuch that they will provide a more accurate depiction of reality of the specific area they aim to target, as opposed to an overarching, all-compassing area that will need to be explored and investigated furthermore determining how and to what degree (if at all) circularity can be employed.

5.4 Energy

5.4.1 The Need for Sustainable Energy Resources

Whenever a crisis such as a pandemic strikes in a city, society is prompted to question the future of the city. This was particularly true during the global COVID-19 pandemic, which saw numerous businesses transform into remote work in a short period of time, while also altering people's transportation patterns and consumption habits, all of which are certain to leave their footprints on the environment in different ways (Jiang, Klemeš, Fan, Fu, & Bee, 2021). In the context of describing the rationale behind the works of Albert Einstein, American theoretical physicist John Archibald Wheeler (1979, p. 2) once said: "In the midst of every crisis, lies great opportunity". The same quote could also be used to describe the logic promulgated by many politicians, policymakers and pundits following the COVID-19 pandemic, as there were calls for fundamental and radical reforms to society in a bid to "build back better" (Dube, 2020, p. 1; Neeraj, Mannakkara, & Wilkinson, 2021, p. 281). The essential concept itself was not new to the COVID-19 pandemic, as it entails identifying the time following a major disaster as a window of opportunity to reform society's use of resources and re-imaging cities as becoming more resilient and sustainable (Hill & Martinez-Diaz, 2020; Mannakkara, Wilkinson, & Potangaroa, 2019). To this end, rapid technological development will have a considerable impact on building sustainability (United Nations, 2019a).

This is particularly true in regard to the energy sector. Already prior to the COVID-19 pandemic, several major cities around the world were experiencing either hard or nascent energy crises (Chevalier & Geoffron, 2013; Newton, 2013). In fact, the energy crisis has become a global problem in no small part due to an ever-increasing surplus population, a generally escalating increase in demand and a continued dependence on fossil-based fuels (Coyle & Simmons, 2014; Suresh, Sebastian, & Brar, 2021). The energy issue is highly relevant to building sustainability because it is closely connected to the increase in greenhouse gas concentration levels, which, in turn, results in disastrous effects on the world climate and the society and world economy at large (Coyle & Simmons, 2014). As of 2017, the largest resources used to produce the world energy are coal (38.30%) and gas (22.90%), two of the most environmentally detrimental types of energy resources (Srivastava & Ramamurthy, 2021). It is important to differentiate between the different types of energy resources. The *primary* resources are ready for end-use, such as electricity, whereas the *secondary* energy resources require matter being converted into another form, such as batteries, fuel etc. (Sulaiman, 2021).

5.4.2 Primary Energy Resources

For long, the issue of finding means to generate sustainable energy has been a major concern for cities all over the world. The problem is finding primary energy resources that are able to combine optimal levels of energy with the least amount of environmental impact (Sulaiman, 2021). Reliance on non-renewable energy sources, such as coal power plants, will most certainly cause pollution and smog (Duling, 2019). This, in turn, is associated to numerous health problems and even premature death (Gardiner, 2019; Hales, 2021). Gas and oil are also known to be main contributors to the degradation of air quality (Caswell, 1993). Biomass is another known source for fuel, which consists of biological raw material (plant or animal material). There is some contention regarding as to whether or not biomass should be considered a more favourable option as opposed to coal, but the fact remains that there are many other types of energy sources that are both cleaner and more efficient (Baimes, 2015; Danish & Wang, 2019).

In contrast, nuclear power has one of the lowest levels of fatalities per unit of energy generated compared to other energy sources, when considering air pollution and accidents (Jain, 2021). Nuclear fusion technology holds great potential as a future source of efficient and clean energy as nuclear plants produce no greenhouse gas emissions while serving as a source of consistent and affordable energy (Mathew, 2022). Also, a 2021 report by the European Commission (2021, p. 182) concluded that there is no "evidence that nuclear energy does more harm to human health or to the environment than other electricity production technologies already included in the Taxonomy as activities supporting climate change mitigation". In addition, nuclear power plants are also powerful and consistent, producing the maximum energy for which they were designed at more than 90% of the time (Srivastava & Ramamurthy, 2021). As of August 2022, there were 438 operable power plant reactors in the world, with roughly 150 under or awaiting decommissioning, along with more than 50 additional plants planned across various cities around the globe (Deffrennes, 2022; International Atomic Energy Agency, 2022b). However, as of 2021, nuclear power only accounts for roughly 10.2% of the global energy production exceeding 25,700 TWh (Srivastava & Ramamurthy, 2021, p. 222). Although nuclear power is currently unrivalled in terms of energy potency, the world would need roughly 14,500 plants in order to cover the current and immediate future energy needs globally, which in and of itself would not be feasible due to the lack of viable sites (Ramaiah, 2020). Uranium, which is used as fuel for nuclear reactors, requires large amounts of energy to mine, and scaling up to that quantity would require more deposits, which may be harder to find in the future (Mudd & Diesendorf, 2008; Pearce, 2008). Nuclear power plants are generally costly to build and maintain, but operate at low fuel costs (Aggarwal, 2021). There is also the issue of nuclear plants producing high-level radioactive waste with long half-life. There is ongoing research seeking to find efficient ways of processing radioactive waste, including technologies aiming at ceramic-based solidification and even destroying the radioactive waste by means of supercritical water oxidation among others (Sun, Bailey, Gardner, & Hyatt, 2022; Xu et al., 2021). Nevertheless, there is still an additional public stigma of "radiation phobia" tied to the very existence of toxic waste, which is often invoked and exacerbated by critics of nuclear power for ideological purposes (McCombie & Jefferson, 2016, p. 768). The cost of building nuclear power plants, their sheer size and the land use their sites claim, along with the political sensitivity of running them, presents some of the gravest challenges to nuclear power plants.

There are, of course, renewable types of energy, with wind and solar being touted as two of the "cleanest" types of primary energy resources (Nagy, 2018; Sulaiman, 2021). However, studies have shown that wind power technology has a significantly greater environmental impact than either nuclear power or hydropower (the latter of which will be discussed in more detail later) (Siddiqui & Dincer, 2017; L. Wang et al., 2019). This is particularly an issue during the manufacturing phase of the wind turbines, since they necessitate special materials and may require substantial tracts of land (McCombie & Jefferson, 2016; Siddiqui & Dincer, 2017). There are also potentially other, more profound, detrimental long-term effects caused indirectly by wind power. Given its supple, light and robust characteristics, wood from the *Ochroma pyramidale*, more popularly known as the "balsa tree", is often used as a core material in parts of the blades of many wind turbines (Borrega, Ahvenainen, Serimaa, & Gibson, 2015). Typically, the blades of a wind turbine stand at approximately 80 metres (262.5 feet), with some blades extending up to 100 metres (328 feet), along with future developments towards blades extending 140 metres (459.5 feet) (Rao, 2019; Van Wijk, van der Roest, & Boere, 2017). That roughly translates to an average of 150 cubic metres (5,300 cubic feet) of balsa wood needed to manufacture a single wind turbine unit with 100 metre blades (i Dalmases, 2021; McGillis, 2021). Ecuador is the world's main supplier of commercial balsa wood, accounting for up to 95% of all exports, of which China claims approximately 78% with an ever-increasing demand due to various Chinese wind energy projects (Jacoby & Gupta, 2021; Tomaselli, 2020). The massive increase in demand for balsa wood, or "balsa fever", has had direct impact on the deforestation of the Amazon following both legal as well as irregular and illegal logging with severe impact on the Indigenous peoples living in the area (i Dalmases, 2021).

This is somewhat of a "green paradox" as the ambition to secure more environmentally friendly energy solutions in the cities could, in fact, end up cannibalising on Earth's natural resources elsewhere. A solution to this problem could be to find a substitutable material, such as polyvinyl chloride (PVC) or polyethylene terephthalate (PET), or some other artificial admixture (Larsen, 2009). Yet, another possibility would be plantation-grown balsa trees. Admittedly, such does exist, albeit in limited scales. Most notably, so in Papua New Guinea, the world's second largest export nation of balsa wood (Jenkin, Minimulu, & Kanowski, 2019; Kotlarewski, Belleville, Gusamo, & Ozarska, 2016). Notwithstanding, it may be difficult to provide a plantation with a tenable provenance (i.e. was part of a rainforest deforested in order to make room for the balsa plantation or is there any risk of more rainforest being slashed and burned in order to expand this plantation once the demand grows etc.?).

Also, another problem that applies to both wind and solar power is that they are costly in proportion to the energy they generate. For instance, wind power requires vast areas of "wind farms" and it is also an intermittent/variable energy source, meaning it cannot be dispatched on demand (Breeze, 2016; European Wind Energy Association, 2009). To put this into perspective, in order to power some of the major cities exclusively with wind power, the wind farm would in many cases need to be as large as the city itself, and often much more than that. For example, Tokyo, Japan would need approximately 10,310 (offshore) turbines, covering an area corresponding to 485% of the area covering the entire city (Board, 2018; RS Components, 2022). Another drawback is that it only supplies variable output, which may be consistent on an aggregated year-to-year basis, but it varies immensely over shorter periods of time (Breeze, 2016; European Wind Energy Association, 2009). Hence, it needs to be combined with other power sources in order to secure a steady supply. Also, wind farms impact on the local wildlife to varying extents (Jameson, Reeve, Laubek, & Sittel, 2019). Certainly, wind farms can be built offshore, but these are difficult to build robustly and securely in waters deeper than approximately 60 metres (197 feet), after which a floating-wind-anchored turbine anchored on the ocean floor would be needed (Hanif, Nadeem, Tariq, & Rashid, 2022). However, seismic activity and weather phenomena at sea, such as cyclonic storms, can damage the wind turbines (Mardfekri & Gardoni, 2015). Also, high maintenance costs are a vital factor that could impede the development of offshore wind farms, with the general maintenance costs being two to three times higher than those of onshore wind farms (Ren, Verma, Li, Teuwen, & Jiang, 2021).

By the same token, solar energy also comes with a high purchasing cost for the solar power system, which, beyond the solar panels themselves, also includes inverters, batteries, wiring and the actual installation thereof (Kumar, 2017). While lauded as a "green" form of energy, there is actually some pollution associated with the manufacturing and transportation of the solar panels, which contribute towards the emission of greenhouse gases, as well as some toxic and hazardous materials used during the manufacturing process of the solar photovoltaic systems (Manglik, 2021). The panels also use vast land areas, especially if they are intended to produce electricity in any larger quantities (Abid, Obed, & Al-Naima, 2018). An added problem with solar power is that the energy has to either be used instantly, or stored (most commonly) in large batteries (Ahluwalia, 2019). A 2018 American study found that meeting 80% of US electricity demand with wind and solar would require either a nationwide high-speed transmission system with the capacity to balance renewable generation over hundreds of kilometres, or alternatively 12 hours of electricity storage for the entire system (Shaner, Davis, Lewis, & Caldeira, 2018). As of today, a battery storage system of that size would cost more than US$2.5 trillion (Milne, 2020).

What is also true for both wind and solar power is that the turbines and panels respectively, are difficult, if not impossible to fully recycle. Wind turbines have a lifespan of approximately 20 years, whereas a solar panel can be used somewhat longer, between 25 and 30 years (Blazev, 2015; Simkins, 2020). Decommissioning wind turbines is expensive, sometimes US$532,000 per wind turbine (Johnston, 2021; Orr, 2019). For offshore wind turbines, the cost is anywhere in the range of US$223,000–US$668,800 per megawatt (MW) (Invernizzi et al., 2020). For solar panels, there is currently a dearth of data concerning the decommissioning cost (Powicki, Libby, & Shaw, 2021). However, extant data stipulates an approximate cost of US$60,000 for a ground-mounted 2 MW solar panel system, meaning the cost would be roughly US$30,000 per MW (Invernizzi et al., 2020).

Although some material can be recycled, the large blades cannot, and are often buried in vast landfills. While certain solar panel components may be recycled, such as the aluminium frame, many other parts are not quite as recyclable (Jariwala & Soni, 2021). For instance, the solar panel's photovoltaic system ends up much the same way, in landfills, where they release toxic materials into the earth (Jariwala & Soni, 2021; Simkins, 2020). It is anticipated that turbine blades are set to account for 43 million tonnes (47.4 million US Tons) of waste in 2050, however, in 2021 wind turbine maker Vestas announced that they were working on a new technology seeking to separate the glass or carbon fibre from the resin in the blades, thereby enabling them to become recyclable (Barsoe, 2021; Fonte & Xydis, 2021). As most solar panels in use today are only a few years old, worn-out panels will not become a major problem for a couple more decades. Nevertheless, one must not belittle the future consequences of leaving them unchecked and there needs to be an incentive for companies and researchers to already now come up with ways to optimise recycling in this area. As an added economic incentive, a 2016 study estimated that the recyclable materials in old solar modules will be worth US$450 million in recoverable assets by 2030 and US$15 billion by the year 2050 (Vargas & Chesney, 2021; Weckend, Wade, & Heath, 2016).

Hydropower is another option often used in many parts of the world. It is often regarded as a sustainable mode of energy production since it does not directly produce carbon dioxide or other atmospheric pollutants while also providing a comparatively consistent source of power independent of weather (Chang, Liu, & Zhou, 2010; Sadler, 2020). However, it requires proximity to a sufficiently energetic source of water, e.g. a river or an elevated lake (Bartle, 2002). Also, hydropower tends to carry a direct impact on the environment, most notably during its manufacturing stage (L. Wang et al., 2019). "Rain power", may, with the help of future technology, present an alternative. Rain is effectively one of the last unexploited energy sources in nature (Guigon, Chaillout, Jager, & Despesse, 2008). Rainfall around the world holds billions of litres of water, which would theoretically have an enormous potential in generating power.

An example of a future technology aimed at harvesting energy from rain is the "all-weather solar panel", along with other types of technologies based on the same principal concept (Chua, Hor, & Lim, 2016; Hajizeinalibioki, Saez, Klymenko, & Arellano-Garcia, 2018; Vibhute & Shukla, 2016; Xie et al., 2020). The main concept revolves around a solar cell panel resting on an array of piezoelectric crystals, which vibrate and generate electricity upon collecting raindrops (Bhuvaneswari, Maheswari, Chandraprakash, & Deepak, 2021). This type of technology (should it ever come to fruition) would be most beneficial in cities with large quantities of sunshine and rainfall, e.g. cities placed along the tropical and equatorial zones such as above the Tropic of Cancer and Capricorn (Bogdanowicz, 2021; Hajizeinalibioki et al., 2018). However, the challenge, thus far, is that only a mere fraction of the kinetic energy of the falling rain drops can be converted because of the energy dissipation within the material of the thin-layer solar panel, so the technology is yet to be optimised before it can become a viable reality (Hajizeinalibioki et al., 2018).

At the end of the day, it is important to remember that no renewable energy resource is self-producing, nor is it able to decommission itself. In the words of Simkins (2020, p. 201), "it cannot be produced or dismantled and recycled from the electricity it generates". To that end, all types of energy resources will have some form of environmental impact in the area in which they are deployed, and even renewable types of energy will need machinery and industries that will not be powered by renewable energy (Moriarty & Honnery, 2011). For instance, the production of concrete and steel for wind turbines, along with glass and solar cells for solar photovoltaic panels as well as aluminium and silicon microchips for computers all need concentrated high temperatures that mere electricity or even biofuels are not able to deliver (Heinberg & Fridley, 2016). For all intents and purposes, renewable energy is subsidised by and dependent upon fossil fuels, and a rapid increase in production and deployment of renewable energy technology will necessitate an increase in fossil fuel consumption and resource extraction, leading to a gradual environmental degradation (Simkins, 2020).

The point of the matter is that renewable energy for the foreseeable future can and will be needed in order to mitigate the effects of climate change. However, they cannot fully and completely replace fossil fuels. This means that fossil fuel will most certainly continue to impact the environment in the future, but expectedly much less so. In this, carbon capture and storage (CCS) could play an important role in the future. This entails a process in which carbon dioxide (CO_2) is captured before it enters the atmosphere, transporting it, and storing it (carbon sequestration) for centuries or millennia, as a means of protecting the environment (Rackley, 2017).

Much of the popular and political discourse concerning energy has been about introducing "green energy" first and replacing the use of coal/gas/oil second, when ideally the discussion should be the other way around. By focussing on ways to substitute non-renewable, toxic resources, one does not risk ending up in a scenario where public hype mandates the introduction of purportedly "clean" forms of energy while not being able to supply enough energy to meet the public demand. The risk by decommissioning nuclear plants and hydropower etc. is that once the energy deficiency becomes untenable, the "quick fix" is to fire up the coal, gas and/or oil plants. Thus, the environmental benefits of migrating to "clean" energy would effectively become a moot point.

This scenario was one that Sweden faced in 2019–2020, when Sweden decommissioned two of its four reactors of its oldest nuclear plant *Ringhals*, although the main cited reason was due to financial purposes on the owner's behalf (O. Tang, Rehme, Cerin, & Huisingh, 2021). However, political ideology has played its fair share as well, as Sweden had already previously decommissioned both nuclear reactors belonging to the *Barsebäck* plant in 1999 and 2005 respectively (Holmberg & Hedberg, 2017; Meyer, 2022). In addition, five more reactors were reportedly slated to close by 2028 due to slow-moving political decision making regarding the construction of a final waste repository for storing spent fuel (Buli & Johnson, 2021). This was set to drive the cost of electricity up markedly (Starn, 2021). To this end, the Swedish government finally approved a waste repository site in January 2022, using a new method called "KBS-3" (nuclear fuel safety, sv: *kärnbränslesäkerhet*), which involves storing the spent nuclear fuel in copper containers surrounded by bentonite clay and placed in 500 tunnels 500 metres (547 yards) under the ground (Duxbury, 2022; Fernández et al., 2022). However, some critics have raised concerns regarding the copper capsules, contending that they may not be as corrosion-proof as they have been made out to be (Enfors, 2021).

Nevertheless, the extant energy supply began running low towards the autumn of 2021. In response, the oil power plant in the city of Karlshamn started its operations already in the month of September 2021, when it is usually used only in winter, during the coldest days of the year (The Local, 2021). This should be contrasted with the Swedish government's stated 2016 ambition that all electricity should be 100% renewable by 2040 (Holmberg & Hedberg, 2017). Though, an added complexity in the Swedish case is that while there may at times be sufficient, or even a purported abundance of, energy in absolute terms in some of the cities, various regulations and conflicting policies on regional and national levels contribute towards creating a de facto capacity deficit in actually supplying and distributing the power in certain parts of Sweden (Lindboe, Hans Henrik, Hagman & Christensen, 2016; Rao, 2019).

Another even more acute case occurred in Lebanon, on October 9–10, 2021, when practically the entire country lost its electricity after the country's two power stations, Zahrani and Deir Ammar, shut down after having run out of fuel, causing a national outage (Hubbard, Saad, & Bengali, 2021; Reuters, 2021). The outage ended only after the Lebanese army delivered six million litres of fuel out of its reserves (Reuters, 2021).

In Germany, political anti-nuclear sentiments in the early 2010s caused the country to decommission all of its nuclear plant throughout the early 2020s, in spite of nuclear power accounting for roughly 11.9% of the country's energy supply in 2022 (Abbondanza, 2022; International Atomic Energy Agency, 2022a). While Germany has availed itself to utilise "green energy" in the future, there are concerns these political decisions will lead to an increased German dependency on fossil-fuelled power plants in the event of weak wind or solar resource conditions (Maennel & Kim, 2018). Alternatively, a pending energy crisis given its 2019 decision to also close all of its coal plants by 2038 (presently the country's largest source for power generation), or an overdependence of gas import along with all the political ramifications that may follow (Telli, Erat, & Demir, 2021; Westphal, 2020). A prelude of predicament was seen during the 2022 Russian invasion of Ukraine. Amidst calls for widespread international boycott of Russia, German chancellor Olaf Scholz announced he was not willing to fully boycott the import of Russian energy, given that Germany relied on Russia for roughly 55% of its natural gas, 35% of its oil and half its coal (Fischer, Küper, & Schaefer, 2022; Schuetze, 2022).

To this end, there are some nascent future technologies that seek to optimise the trade-off between efficiency and environment-friendliness. For instance, various projects concerning "small modular reactors (SMRs)" have been launched in numerous countries throughout the twenty-first century. For instance, on October 12, 2021, France announced its intention to invest US$35 billion in the construction of multiple SMRs to be completed by 2030 (Corbet, 2021; Seibt, 2021). In December 2021, China was reported to have started the word's first SMR, a 200 MW reactor located at Shidao Bay Nuclear Power Plant in Rongcheng, in the eastern extremity of the Shandong Province (Bloomberg News, 2021; Ingersoll, 2021).

An SMR can essentially be described as a small-scale nuclear plant (Todreas, 2021). It generates a smaller amount of the energy of a conventional nuclear plant, each one generates less than 300 MW, as opposed to conventional nuclear plants, which are able to produce between 950 and 1,600 MW (Seibt, 2021). In return, SMRs are designed to be cheaper, safer and faster to manufacture. While a traditional power plant may cost billions of dollars and take up to a decade to build, SMRs can be built in just 4 years, including 500 days on-site for the modular build (Delbert, 2020). Furthermore, they cover only 10% of the area a nuclear power plant would (40,000m^2 rather than 400,000m^2) (Delbert, 2020; Rolls-Royce, 2017).

The ambition of a single SMR would be to power a neighbourhood rather than an entire city. However, major impediments to adopting SMR are financing as well as the licensing process, since SMRs were originally developed for conventional, custom-built reactors, preventing the simple deployment of identical units at different sites (Mignacca, Locatelli, & Sainati, 2020; Sainati, Locatelli, & Brookes, 2015). In this, adopting a CE lens could help bring progress to the advancement the sustainability of SMRs. Specifically, already at the early design stages, there needs to be particular consideration that SMR modules be designed for disassembly, and that the models are designed to be replaceable, thereby creating a market for second-hand modules (Mignacca et al., 2020). Admittedly, the contamination of SMR modules could limit the reuse to some degree, along with the challenges of transporting the modules in a safe, economical and practical manner, particularly if the modules are contaminated (Mignacca & Locatelli, 2021). Thus, a new licensing and regulatory framework concerning the reuse of SMR modules would likely need to be created (Mignacca & Locatelli, 2021; Mignacca et al., 2020). There are of course, other disadvantages as well. The aforementioned "radiation phobia" is present also with SMR, making it more difficult to sell the concept of SMRs in a successful manner. However, the most prominent drawback is the increased running costs with each kilowatt hour (kWh) of electricity from an SMR carrying an anticipated fuel cost between 15% and 70% more than a kWh of electricity produced in a full-sized nuclear power station (Pannier & Skoda, 2014). The reason for this is the "economies of scale" in which power output decreases while other costs remain constant, thereby creating an imbalance that needs to be accounted for by means of higher electricity costs (Monk, 2016).

There are, of course, other promising energy developments as well. For instance, arguing that nuclear power was the only carbon-free source that could reliably and constantly deliver energy, Bill Gates announced in 2021 that he had invested hundreds of million dollars into launching a company to design a future next-generation sodium nuclear plant in Wyoming (Gates, 2021; Gruver, 2021). The purported case made for this solution is that the high heat-transfer properties of sodium will allow the plant to be air-cooled, enabling the plant to be shut down quickly in the event of an emergency (Gruver, 2021).

Launched in 2006 in the Chinese city of Hefei, Experimental Advanced Superconducting Tokamak (EAST) is an experimental superconducting tokamak magnetic fusion energy reactor (B. Wan, 2016). A "tokamak" is a device that uses a powerful magnetic field to confine plasma in the shape of a torus (or a "donut shape") (G. T. Pope, 1994). Its aim is to achieve fusion energy in a manner similar to how the sun produces energy, hence the project the researchers are working towards is often referred to as an "artificial sun" (T. Wang, 2021). On December 30, 2021, the researchers were able to generate a long-pulse high-parameter plasma operation of 17 minutes and 36 seconds (or 1,056 seconds) at approximately 70 million centigrade (Pollard, 2022). The facility had already a few months earlier, in May 2021, managed create a similar plasma operation reaching 160 million centigrade, or ten times the temperature of the sun, albeit only for a few seconds (Makichuk, 2022). Similar nascent reactors exist elsewhere as well, such as the multinational US$25 billion International Thermonuclear Experimental Reactor (ITER) in Saint-Paul-lès-Durance, France (Bigot, 2017; Sharma & Varshney, 2019). ITER is expected to start its testing operations in 2025 and reach full operations by 2035 (Pearson, Antoniazzi, & Nuttall, 2018). This mode of energy is still at an exceptionally early stage and any attempts to harness energy from it in a practically usable manner are still many years away.

Moreover, geothermal energy is a resource that has expanded greatly throughout the twenty-first century. In 2019, it was used by 88 countries compared to merely 28 in 1995 (Lund & Toth, 2021). As an energy source, geothermal energy releases exceedingly little greenhouse gas emission compared to other energy resources (Bhagaloo, Ali, Baboolal, & Ward, 2022). Geothermal energy is a resource that is completely unrelated to the controversial method of energy extraction commonly referred to as "fracking"

(Keeler, 2016). In short, fracking entails injecting fluids consisting of water, sand and chemicals at high pressure into rocks containing shale gas as a means of creating openings allowing the gas to be released (Meng, 2017). Geothermal energy, on the other hand, entails pumping warm water out of reservoirs and passing it through a heat exchanger (Postrioti et al., 2016). As such, it does not require breaking into geographic formations in the way that fracking does. To this end, the development of geothermal energy is showing great potential as new methods are evolving to tap energy deeper beneath the Earth's crust in ways that are more commercially viable than before (Diaz, 2021). Future endeavours could, for instance, involve drilling into volcanoes in order to utilise the extremely hot water and magma deposits, with the ambition of developing these high-temperature resources into even more effective geothermal power stations, perhaps even ten times more effective than today (AlMuhaideb & Noynaert, 2021; Skinner, Abbiss, Banks, Fyfe, & Whittaker, 2021). As a case in point, Iceland has been trailblazing in the development of geothermal energy (Kelly & Fretwell, 2018). This should be viewed in light of its relatively small landmass and population, and its high concentration of volcanoes, where geothermal power now constitutes approximately 27% of the total electricity generation, as opposed to roughly 0.3% globally (Meier, 2020). The Hellisheiði Power Station and the Nesjavellir Geothermal Power Station are the two largest geothermal plants, each with a capacity of 303 MW and 120 MW respectively (Ragnarsson, Steingrímsson, & Thorhallsson, 2021).

An even more articulated example is Kenya, which is set to secure a majority (51%) of its electricity from geothermal power in the coming decade

Image 10.1 Nesjavellir, the second largest geothermal power station in Iceland, located in the city of Thingvellir.

Source: Gretar Ívarsson, Public domain, via Wikimedia Common.

(Klagge & Nweke-Eze, 2020; Meier, 2020). While wind and solar power in general, require less land use than hydropower or coal, geothermal plants claim even less land area than wind and solar plants, while also using less water per kilowatt than fossil fuel power generating technologies (Flavin, 2008; Mansoori, Enayati, & Agyarko, 2016). Notwithstanding, having hundreds of plants scattered across any deposit-rich area would naturally impact both the scenery and the wildlife. A future solution to this problem could be offshore geothermal drilling. This could also make geothermal energy a practical consideration for more nations and especially so for coastal megacities (Lamond, 2013). Also, unlike other renewable energy sources, such as wind and solar plants, geothermal systems are "baseload energy", meaning they are operational regardless of weather conditions or seasons (Stober & Bucher, 2021). Still, future measures will be needed to thoroughly investigate and, if necessary, mitigate the possible seismological instability caused by geothermal plants, as well as further reducing its methane emission (Razi & Ali, 2021).

5.4.3 Secondary Energy Resources

Needless to say, there is also a need for more sustainable secondary energy resources. To this end, one of mankind's greatest banes in regard to secondary energy resources has been the inability to invent a battery durable and strong enough to fully replace the use of non-renewable energy (Goode, 2018). Even if progress is being continuously made in increasing battery capacity, there is still a long way to go before they are efficient enough to equal that of most current large-scale fuel-driven motors (Andrea, 2020; Lin, Liu, & Cui, 2017). For instance, powering a jumbo jet with a battery corresponding to the same capacity as jet fuel would require approximately 545 tonnes (1.2 million pounds) worth of today's batteries just to generate the power of the jet engine it would be replacing, meaning that the weight alone would require an additional eight jet planes (University of Houston Energy Fellows, 2021).

There are, of course, some alternatives, but they come with their own disadvantages. Hydrogen is cheaper to refine and more environmentally friendly to burn than petrol (Alverà, 2021). However, it is considerably more dangerous to handle, in part given its explosive property, and in part given that it is stored in liquid form (Teichmann, Arlt, Schlücker, & Wasserscheid, 2016). The latter means that the hydrogen would need to be compressed and massive quantities of energy would be lost in the process, in turn negating the efficiency of the engines (Hübert, Boon-Brett, & Buttner, 2016; Olorunnisola, 2018). Also, this is not having accounted for the added massive cost of having to convert all cars and petrol stations into becoming hydrogen-based. For aircrafts, hydrogen is being developed on a small scale by companies such as Airbus. The company has developed a concept design for a plane series called "ZeroE" with one model designed to carry 200 passengers over approximately 2,000 nautical miles (3,704 km), although this model is not expected to be launched until 2035 at the earliest (Alverà, 2021; Boretti, 2021).

Image 10.2 Airbus "ZeroE" concept design.
Source: Airbus.

Fuel cells are sometimes also presented as an alternative to batteries. In theory, fuel cells would make batteries obsolete since they do not run down or require recharging (Bejan, Dincer, Lorente, Miguel, & Reis, 2004). Rather, it works by converting hydrogen (most commonly, though methane or methanol may also be used) and oxygen into water, thereby generating electricity (Hordeski, 2020; Lindorfer, Reiter, Tichler, & Steinmüller, 2019). As long as these chemicals are present, the fuel cell will operate. Fuel cells are environmentally friendly alternatives with near-zero or zero emission, depending on the chemical used (J. Wang, Wang, & Fan, 2018). However, they are inherently expensive, and hydrogen is, as previously mentioned, difficult to handle and store (Olorunnisola, 2018).

In the future, it is possible that solar fuel may become a more viable option. In simple terms, solar fuel is a synthetic chemical fuel produced from solar energy. Solar fuels can be produced through a series of different methods, but the common denominator is that light is used as an energy source, in which solar energy is transduced to chemical energy (Gray, 2009; Lips, Schuurmans, Branco dos Santos, & Hellingwerf, 2018). Solar fuel may be produced and stored for later use, such as when sunlight is not available, thereby presenting itself as an alternative to fossil fuels and batteries. Solar fuel is considered one of the most abundant and environmentally friendly energy sources, although its power density is markedly lower than for most other types of energy (Styring, 2012; Xiang et al., 2019).

One approach that is regularly used is "artificial photosynthesis", which is similar to how natural photosynthesis in plants works by using only water, carbon dioxide, and sunlight to generate fuel (Amao, 2011). There is a selection of different fuels one can produce. One is making hydrogen fuel by using solar energy to split water (Pagliaro & Konstandopoulos, 2012). Another is using solar energy to produce alcohols, e.g. ethanol and methanol (Monnerie, Gan, Roeb, & Sattler, 2020; M. Wang, Luan, & Lu, 2020). Given the aforementioned challenges with hydrogen, researchers have begun considering some of the other fuel alternatives synthesisable via solar fuel (Hasan et al., 2021). To this end, ammonia has become increasingly more regarded as a substitute for indirect storage. It is known that at reasonable pressures, ammonia is easily contained as a liquid (Z. Wan, Tao, Shao, Zhang, & You, 2021). As a synthetic fuel, ammonia can be used in fuel cells or combusted in engines and gas turbines (IRENA, 2020). In this form, energy density is roughly half of that of petrol and ten times more than batteries (Hasan et al., 2021).

5.4.4 Hybrid Energy

Regardless of their properties, one should not view any of the aforementioned energy resources as a panacea to the energy issue as such. Rather, sustainability is achieved through the optimisation and combination of various forms of technologies, while making cities less dependent of the polluting types of energy resources. However, the extraction of cleaner types of energy needs to be optimised, and for this technology needs to advance. For instance, solar photovoltaic panels and wind energy could be utilised as a form of a hybrid energy storage system with batteries and ultracapacitors that ensures the continuity of energy (Aktas & Kirçiçek, 2021). Ultracapacitors (also known as "supercapacitors") possess a high-power density compared to batteries and are therefore able to quickly meet high-power demand for a short time, while batteries have a higher energy density than ultracapacitors (Aktas, 2021; Aktas & Kirçiçek, 2021). In a hybrid energy storage system, the ultracapacitor would meet the sudden demand for energy, whereas the battery would meet the long-term/continuous energy demand. This would optimise solar and wind energy and make them considerably more viable (Aktas & Kirçiçek, 2021).

Though given the future increase in demand, especially during times of pandemics, a power generation mix will be necessary, i.e. to combine these renewable types of energy with other types of energy (Herath, 2021). SMR, geothermal energy, nuclear power and to a certain extent even hydropower, will need to develop and be used in combination with each other and with solar and wind power so that they can all play future roles in ensuring that the smart cities are fully powered, resilient and future-proofed (Brook et al., 2014; Herath, 2021). Non-renewable energy plants are not desired in the best of worlds. However, from a strictly pragmatic point of view, they will continue to exist around the cities as their energy/fuel production is in no uncertain terms more reliable. Moreover, there will also be an occasional need for off-site non-renewable resources to power auxiliary functions, such as heating and cooling if and when the renewable plants are not operating or are not supplying enough power due to unexpected peaks (Keller, 2021). Still, as prices for CO^2 emissions continue to rise, along with the prices of non-renewable resources, other options, most particularly wind and nuclear power, will most likely become more attractive alternatives (Frank, 2016).

Additionally, one may expect to see an increased presence of distributed energy resources (DER) in future smart cities, as the energy grid becomes more dynamic (Atasoy, Akınç, & Erçin, 2015). In essence, DER signifies a form of electrical generation and storage carried out by different small, grid-connected or distribution system-connected devices (Hernández & Enríquez, 2019). Most traditional power stations, such as coal plants, gas plants, nuclear plants, hydroelectric dams and solar power stations are centralised and generally require electric energy to be transmitted across long distances. Conversely, DER systems are decentralised, modular and more flexible technologies located in closer proximity to the load they serve (Hentea, 2021). DERs can comprise multiple generation and storage components and may, in such instances thus be referred to as "hybrid power" or "hybrid energy" systems (Shah, 2021). DER systems will often use renewable energy sources, and hence they can play an important future role in reducing carbon emission. At present, DER's weakness is its limited capacity, consisting of approximately 10 MW or less (Hentea, 2021). As battery development improves, as well as other future technologies aimed at generating energy, such as flywheel energy storage (FES) or vehicle-to-grid, DER will have a potentially wider use in the future smart cities (Castelvecchi, 2007; Kempton & Tomić, 2005).

6 Conclusion

The aim of this chapter was to explore how technology and policies can be applied to help smart cities achieve sustainability and pandemic resilience in accordance with SDG 11. As per the findings, the following action points are suggested for ensuring pandemic resilience.

Action 1: Create a More Harmonised and Transparent Way of Estimating the Protection of Cultural and Natural Heritage

When considering the target of protecting the world's cultural and natural heritage, it is important to remember that the challenges of achieving this goal lies largely in the fact that some countries may use national accounting frameworks that do not clearly distinguish between cultural/natural activities from other types of activities. Furthermore, financial transactions are sometimes later rerouted for different uses in the end, and some financial transactions may even be double-counted at different levels of public administration (UNESCO, 2019). Ensuring transparency is essential to enabling follow-ups and in this, the cities will play pivotal roles in providing data that is accurate and verifiable.

Action 2: Foster Local Agglomeration and Support

Cities could take a greater role in supporting its local talent, wherever the cities have the means/capabilities to do so. The New York initiative "City Artist Corps" is a prime example. While such initiatives may not be a universal be-all and end-all remedy, they do help secure a number of jobs. Furthermore, one should not belittle their symbolic value in helping to raise public morale. In addition, companies and entrepreneurs able to weather the storm could be incentivised via programmes or campaigns to assist struggling artists affected by the pandemic, thereby facilitating an intellectual kind of "contagion" or agglomeration. The knowledge and resources available at the universities (or other institutions of higher learning) could also be maximised such as receiving public or private sponsorship to offer programmes or hubs to offer various support and/or reskilling initiatives for struggling artists to earn their upkeep throughout the pandemic.

Action 3: Ensure That Sites/Buildings Are Designed with a Pandemic Contingency

Making sites more accessible during times of pandemics means that new constructions should be designed with a "pandemic contingency" in mind wherein it is possible to keep audiences/visitors safely isolated, or adequately social distanced from one another with proper disinfections in-between visits of the areas guests have frequented. In already existing buildings, it may be necessary to redesign some of them so that they can at least temporarily and on short notice ready themselves to adhere to the various safety protocols mandated by the authorities.

Action 4: Digitise More Cultural Sights and Activities

A "digital first" or hybrid digital-offline context option may assist cultural events to keep running in spite of a raging pandemic. New technology proffered by VR and/or AR tools will enable many organisations to keep their activities running, and the cultural sector will need to adopt this technology so that they may offer this alternative to customers who cannot partake in various activities due to lockdowns etc. wherever it is possible and/or suitable to do so.

Action 5: Set Up and Utilise More Digital Twin Cities

Digital twin cities can help identify the city's chinks in its armour. Through advanced simulations, it can provide valuable information regarding which areas are more likely to be most affected by specific types of events and what precautions to take well ahead of time before said possibility becomes a reality. Massive data will be required for such an endeavour, necessitating collaborative efforts between the cities and academia, along with the corporate sector. The case of Newcastle University and the water services company, Northumbrian Water, illustrates an example of such collaboration.

Action 6: Consider Installing Air Purifiers in the Worst Polluted Places

At the end of the day, there needs to be more tests conducted on the effectiveness of giant outdoor air purifiers. If they are indeed effective, giant mobile air purifiers could be developed to mitigate the worst air pollutions in a city in a much more dynamic fashion while also being able to meet the challenges of pollution seepage into other geographic area caused by factors such as weather, winds and so forth. Having said that, installing air purifiers does not attack the root of the problem, but it can allow for a reprieve, or a "quick fix", to lessen some of the worst pollution in some of the worst-affected areas in certain cities.

Action 7: Consider More Circular Solutions to Waste-Related Problems

Products today are, in many cases, designed with a specific lifespan in mind for the purposes of being discarded after the end of its lifecycle. If manufacturers were incentivised, or mandated, to design products to be more recyclable, or segmented, where defective components could be more easily replaced, much waste would undoubtedly be reduced and more resources would be spared. From the city's point of view, this could be a matter to ensure one also endeavours to consider contractors utilising a circular approach whenever there is a need to procure public material to build infrastructure etc.

Action 8: Dare to Discuss Sensitive Concerning the Future Waste of Green Energy

Tied to the previous point, discussing the negative environmental aspects of "green energy" may be a politically charged issue, but the adverse consequences can eventually be neither avoided nor mitigated unless one starts to prepare for contingencies already now. It is known that wind power blades and solar cells are potential environmental hazards in the future. There needs to be an open discussion involving the cities, along with a plan of what to do with worn-out components.

Action 9: Adopt a More Pragmatic Approach to the Energy Issue

For too long political ideology has gotten in the way of finding practical solutions to the energy issue. The fact of the matter is that there is no universal way involving one single primary resource that can solve the problem. Instead, there must be a combination of different kinds of energy resources aimed at reducing the use of the types of non-renewable resources that releases the greatest amount of pollution. Part of this approach is to understand that the energy issue requires a multidisciplinary solution. This means accepting that while nuclear power can never be the *only* solution, it needs to be *part* of the solution. Nuclear power is a reliable and consistent source of energy that is not contingent on the weather conditions while also being even cleaner than some renewable types of energy (e.g. wind power). As such, the contention of nuclear power versus renewable energy should not be "either/or" but rather that of "both/and". Naturally, renewable resources such as geothermal plants, as well as wind and solar energy should be utilised wherever viable, but non-renewable resources will need to continue existing primarily as back-up options, though they should not be the initial go-to solution. Also, DER can help mitigate the negative impacts of non-renewable resources. As such, a hybrid energy solution would seem to hold the most realistic and optimal potential for securing the future demand for energy while minimising damage on the environment. Utilising hydrogen or synthetic fuels such as ammonia or hydrazine can extend the viability of batteries. With future technology, solar fuel may also be a way to extract fuel in an even "cleaner" and more sustainable manner.

Action 10: Deploy SMRs Wherever Needed in Order to Safeguard against Local Outages

Some cities and city districts are more adversely affected than others. In these areas, SMRs could proffer a solution. The shorter construction time (as opposed to a nuclear plant) means SMR can offer a more sustainable mid- to long-term solution. However, the current licensing and regulatory framework present in many countries and cities has a stymieing effect and will need to be adjusted in order to accommodate for newer energy solutions such as SMRs.

Action 11: Utilise More Off-Shore Energy Resources Where Possible

By utilising off-shore resource harvesting, such as future geothermal and wind power, it is possible for coastal cities not only to save valuable land areas that can be used for other purposes, such as urban development and expansion. Moreover, off-shore energy plants/farms makes it possible to tap into resources that may not otherwise have been accessible to the city. Naturally, due consideration needs to be made in regards to wildlife, seafaring and other possible factors possibly affected by off-shoring in determining their geographic placement.

Action 12: Dare to Engage in New Initiatives Seeking to Optimise Green Energy

Many of the existing renewable resources still have a long way to go before they can become as viable and consistent as the non-renewable resources. Fortunately, there is constant progress made with new discoveries. For instance, "rain power" may, with the help of future technology, present a viable resource. However, there will undoubtedly be many more initiatives. In this, cities could have a part in helping to foster entrepreneurial spirits aimed at perfecting renewable energy harvesting, by launching various campaigns or hosting certain programmes in which entrepreneurs could receive either funding or resources from a city fund, in which they intend to try out their invention. If successful, the city could be the first to benefit from the new technology.

Concluding Remarks

Building a sustainable society in a smart city during and after a pandemic entails many challenges. SDG 11 covers a broad scope, and some of them have served as talking points for this chapter. While SDG 11 sets its sights on 2030 as a goal date, sustainability as discussed in this chapter has no set end date, but is rather a continuous process. As such, protecting culture, society and environment is essentially what lies at the heart of ensuring sustainability.

Future technology proffers much potential in ensuring that sustainability is enabled in some cases and optimised in other cases. However, while science is quintessential, it is important to remember that sustainability is not merely about devising new and superior technology that may present a "fix-all" solution. Sustainability also occurs on a political and societal level, and one of the most comprehensive challenges in this day and age is ensuring political consensus. Ensuring sustainability will often entail large investments at different levels. By turning it into a party political question, progress is stymied since investments and initiatives in different areas become unreliable since it becomes contingent on whichever party is in office, or what political trend is the "flavour of the day" in an attempt for parties to score points for upcoming elections. Rather, the United Nation's SDGs in general, and SDG 11 in particular, will need to be depoliticised and bi/multi-partisan support should be secured in consultation with academics, city officials and interest groups. A specific policy task force could be initialised in the cities that could offer consultative advice to the lawmakers in regard to securing future sustainability.

Notes

1 As the discussion on the "means of achieving" targets concerns general policy attitudes and modes of governance, the topic is much too broad and peripheral to fall into the remit of this chapter. Furthermore, they do not account for

pandemic scenarios, but rather as a means of facilitating the sustenance of the SDG 11 targets under "conventional" circumstances, and hence their relevance is limited in this particular setting. Thus, the "means of achieving" targets are listed here solely as a matter of reference: (A) *strong national and regional development planning*; (B) *implement policies for inclusion, resource efficiency and disaster risk reduction*; and (C) *support least developed countries in sustainable and resilient building.*

2 For target 1 – see Chapter 4: *Housing.* For target 2 – see Chapter 5: *Infrastructure and Travel*". For target 3 and 7 – see Chapter 2: *Attractiveness.*

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Conclusion

11 Cohesion

The Metropandemic Revolution and Beyond

1 Introduction

The onset of the metropandemic revolution has already begun. As pandemics and disasters have affected cities and societies at large throughout history, there have been important lessons to be had from each one that have, in one way or another, exposed the extant weaknesses inherent in society. The modern digital technology that characterises smart cities will make it possible to utilise data in different ways so that foresight becomes a more viable variable to be reckoned with. In this, cohesion is a fundamental component that binds all aspects of a functioning society together. In other words, cohesion relates to the strength of relationships and solidarity among members of a community (Kawachi & Berkman, 2014; Manca, 2014). Effectively, cohesion will be a functional determinant of the future smart cities in how well they can utilise technology to build pandemic resilience. Those cities that succeed will cope well during a pandemic and will emerge as prosperous in the time following it. By ensuring cohesion, the denizens are more likely to feel a shared sense of values, culture and belonging in the city (Mkhize, 2019).

In this, the metropandemic revolution seeks to build and secure resilience through the interconnectivity of the discussed themes, i.e. *attractiveness*; *labour*; *housing*; *infrastructure and travel*; *welfare and healthcare*; *global hubs*; *digitalisation*; *safety and security*; and *sustainability*. How then can one build *cohesion* between these different aspects? What synthesis is there to be had from the lessons learned in this volume?

COVID-19 has been used as a principal case throughout this book because it changed the world in such a fundamental and widespread manner, although this book's premise also targets pandemics and other types of comparable disruptions on a more general level as well. Though it should be stated that no country, city or community is ever really fully prepared for an epidemic or pandemic (Coccia, 2022).

2 The Trouble with Globalisation and Lean Production

The early stages of the pandemic clearly illustrated the need for cities to become more self-dependant (as opposed to independent, since city-states no longer exist in the way they did hundreds of years ago). By relying on

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the national government, the cities have, by extension, in many cases been relying on the single markets or other modes of globalised trade functions. This, in combination with "lean" production methods such as "just-in-time manufacturing" (JIT), had detrimental effects on the supply chains all over the world (Kovács & Falagara Sigala, 2021).

The "lean" production methods resulted in severe impairments to the supply chain, causing many disruptions following the pandemic eruption since COVID-19 prompted various policies that sought to block the movement of people and materials, which, in turn, had disastrous effects on the production lines and manufacturing capacities (Kovács & Falagara Sigala, 2021). As a result, international mainstream supply chain management was effectively crippled in its response to these disruptions. This was due to the fact that most leading supply chains have been focussed on minimising operation costs, while also adhering to various "lean" approaches designed to drastically reduce, or even eliminate, stockpiling in the interest of cutting back on human labour, physical space and equipment etc. (Kovács & Falagara Sigala, 2021; Spisakovac & Kozlovska, 2019; Swanson & Lankford, 1998). Following the pandemic, there were calls to move away from "just-in-time" manufacturing to a "just-in-case" counterpart, with the contention that resilience will be priced and discounted for by enterprises and governments alike (Brakman, Garretsen, & van Witteloostuijn, 2020).

Globalisation also carries its significant share of the pandemic responsibility. Globalisation can, in simple terms, be defined as:

> [T]he process of creating networks of connections among actors at intra- or multi-continental distances, mediated through a variety of flows including people, information and ideas, capital, and goods. Globalization is a process that erodes national boundaries, integrates national economies, cultures, technologies and governance, and produces complex relations of mutual interdependence.
>
> (Gygli, Haelg, Potrafke, & Sturm, 2019, p. 546)

In many ways, the aforementioned definition captures many of the difficulties in combating pandemics like COVID-19. Studies have shown that there is a clear, positive correlation between the level of globalisation and case fatality rate (CFR) (Farzanegan, Feizi, & Gholipour, 2021; Sigler et al., 2021). While the favourable effects of globalisation on commerce, employment opportunities and international collaboration cannot be denied, some studies have contended that its effects on facilitating the pandemic spread have been detrimental (Shukla, 2020; Tandon, 2020). This is due to globalisation stimulating the mobility of people internationally, which was a contributing reason as to why the COVID-19 CFRs increased more in countries with higher degrees of globalisation (Farzanegan et al., 2021). This is an aspect that should not be neglected, since the number of cases, and even more so, the number of fatalities, is ultimately what determines the impact that a disease has on society (Brender, 2014). Also, highly globalised countries tend to be more reluctant to impose travel restrictions, and particularly not through formal political and trade policy integration (Bickley, Chan, Skali, Stadelmann, & Torgler, 2021). On that note, research has shown that travel restrictions were effective in stemming the spread of the COVID-19 virus across the borders during the early stages of the pandemic, and were in some cases, instrumental tools in buying valuable time, although they had limited effect in preventing general local transmission (Gwee, Chua, Wang, & Pang, 2021; Wells et al., 2020). In addition, there were massive delays in the EU in rolling out the vaccine, causing delays not only in the EU but also in other countries as well, such as Japan, due to the need for the EU to approve exports (Kosaka, Hashimoto, Ozaki, Tanimoto, & Kami, 2021; Tatar, Shoorekchali, Faraji, & Wilson, 2021). This caused several EU Member States to break ranks with the EU's vaccination strategy and instead opting to look beyond Europe's borders to secure vaccine shipments (Holt, 2021).

Some studies have posited that globalisation, combined with less digitally advanced cities along with weaker institutions and a general lack of monitoring capabilities and other digital solutions, will amplify the speed of a pandemic eruption (Farzanegan et al., 2021; Whitelaw, Mamas, Topol, & Van Spall, 2020). In contrast, other studies have indicated that the role of globalisation is far more complex and ambiguous and that more studies are needed in order to fully comprehend the role it may or may not have in facilitating pandemic spread (Bickley et al., 2021). The counterpoint one may raise in this regard is, if there is an alternative explanation, or an unknown endogenous factor, to the pandemic spread. This could, for instance, be the extent of which a country has been able to keep the spread down by coordinating border measures with other countries (Lee, Worsnop, Grépin, & Kamradt-Scott, 2020).

This stresses the urgency for policymakers and researchers to gather more data to properly consider the potential health risks associated with increased globalisation of markets and societies. Moreover, there needs to be an increased investment not only in the expansion of health infrastructure, but also in "smart" technology overall in order to secure a greater sense of cohesion and in that, more robust pandemic resilience.

This stresses the advantages of the digital transformation of cities. That is to say, digitalisation serves to create a stronger sense of pandemic resilience while keeping some of the positive business-related aspects of globalisation. Examples include the elimination of business trips, the ability to work from home etc. In this regard, there will need to be additional investment in the expansion of networks and the potentially necessary infrastructure. More specifically, investments in education and the flexibility of work models could bridge the gap between compatibility of digital opportunities, and real work and education structures. In this, increasing digitalisation is closely coupled with productivity gains that can further drive growth and thus produce more goods in less time, and in a way, create an improved and augmented form of "lean" production methods (Blum & Neumärker, 2021).

Given the failure of globalisation in so many determining key aspects during the pandemic, it will be necessary to revamp, or reform, the concept in the future (Ruiz Estrada & Khan, 2020). The lingering question is how to reform globalisation in a manner that safeguards the free movements of goods and services, but in a way that ensures the containment of the pandemic spread, while also ensuring reliable deliveries of health equipment and other necessary amenities and supplies. In the same way that globalisation has concerned itself with the free flow of goods, services and people in the past, a reformed globalisation would have to make room for the free flow of ideas and creativity that serves to improve the lives of millions in the face of future large-scale disruptions (Thangavel, Pathak, & Chandra, 2022). This includes international collaboration in the development of future vaccines and a deeper international collaboration of science, in general. Turning to rigid national protectionism alone will likely not yield the answers needed to solve this problem, but offering more of the same and returning to the same old form of globalisation that failed to deliver when needed with the hopes that it will do so, the "next time around", is nothing short of a foolhardy endeavour (Ruiz Estrada & Khan, 2020; Thangavel et al., 2022). One could thus conceive the notion a possible "globalisation 2.0", in which international trade and innovation etc. remains easily shared, but without having to surrender the national, or regional, sense of agency.

3 The Exclusionary Aspects of Digital Technology

Cohesion is often presented as the antithesis to conflict, with both existing in the cosmopolitan societies that smart cities so often are part of (Collins, 2007; Short, 2020). However, cohesion does not necessarily preclude the existence of conflict, as Kearns and Forrest (2000, p. 1013) concluded that "[…] a nation of highly cohesive cities with strong and distinct images could be one in which shared values and norms are relatively parochial and with wide intercity inequalities of lifestyles and living standards". That is to say, while cohesion and conflict may be each other's polar opposites, they are, by no means. mutually exclusive in a society. This is evident in the case of smart cities, which rely so heavily on digital technology and that its inhabitants have full access to the necessary technology.

A smart city effectively seeks to create cohesion by connecting the themes covered in this volume by means of technology and data-driven strategies. However, the "conflict" that challenges this cohesion lies primarily in that the integral reliance on digital technology will effectively serve to exclude those denizens without access, or capabilities to utilise, digital technology. This "digital exclusion" would mainly affect denizens belonging to low-income backgrounds, the elderly, and the disabled, which, by extension, would risk turning into total a societal/social exclusion of these groups (Gulbrandsen & Sheehan, 2020; Wright & Wadhwa, 2010). Regardless, it should be emphasised that not even industrialised societies are immune to digital exclusion. For example, in 2019, a mere 56% of the surveyed population in the EU had at least basic digital skills (European Commission, 2020b). The lack of basic digital skills poses a serious challenge to digital inclusion, particularly so in the context of rapid digitalisation.

On a broader level, the lack of government policy presents an obstacle to digital inclusion (Chadwick, Chapman, & Caton, 2019; Jaeger, 2015; Miklian & Hoelscher, 2017). On this account, there would be a need for increased political pressure and, in many cases, an updated legislation on a national level in general, but more particularly on a local, city level as well, that seeks to treat accessibility to digital technology in a similar way that the extant legal framework treats accessibility issues in many other areas. As Chadwick et al. (2019, p. 276) writes: "The barriers still exist at a societal level and, although not empirically investigated, they are likely to affect micro-system supports for digital inclusion".

The European Commission (2020a) has proposed to remedy this by proposing that, based on an assessment of gaps in digital skills, all young people who register should be offered a dedicated preparatory training to enhance their digital skills under the so-called *Youth Guarantee* scheme. The Youth Guarantee scheme is a commitment by all EU Member States aimed at securing a smooth transition from school to work, combating unemployment by means of offering employment, apprenticeships or continued education to people under the age of 25 (Selenko, 2019). While the results from Youth Guarantee schemes have been mixed, they can help reduce digital illiteracy and, for this purpose, initiatives like this would do well to be introduced elsewhere outside the EU as well (Hyggen, Kolough-Söderlund, Olsen, & Tägtström, 2018).

4 Understanding Future Smart Cities Cohesion during Pandemics

In truth, not much is known about the possible pandemic impact on the future smart cities. Up until COVID-19, larger spreads of infectious diseases during the modern era were, with some notable exceptions such as the epidemiology of HIV/AIDS, the 1977 Russian flu and the 2009 swine flu etc., mainly endemics rather than pandemics (Dehner, 2012; Snowden, 2019). That means they were a typically regional phenomenon that would affect a limited number of regions, or at most, neighbouring countries (Merrill, 2021). Prior large-scale global pandemics, such as the Spanish flu, occurred in eras long before the existence of smart cities (Snowden, 2019). Hence, pandemic resilience among smart cities is a question that has long been unanswered. The dearth of available literature on this topic is an academic problem this book has sought to address.

On a practical level, this book has sought to provide the reader with a window into the future of urbanisation and the technological developments one may expect to see in tomorrow's cities, while ensuring that they remain functional and resilient to future disruptions such as pandemics. Throughout this book, a number of themes have been explored and many topics have been investigated in regard to the impact of digital development and technology and what the overall ramifications may be for society at large. In particular, this chapter seeks to further elaborate on the conclusions drawn in each of the chapters in a synthesising discussion according to the overarching categories, or the parts of into which this book is divided.

5 Chapter Findings

5.1 Premise

The following section will elaborate on the conclusions and proposed courses of action throughout the different chapters in regard to the overarching categories as stipulated by this book's structure in Chapter 1. The theme of "Part I" of this book was *Appeal*. This theme looked at how the factors relating to how a city can secure its overall appeal and prospects of creating a life for oneself in the city. Part II, *Facilities*, discussed how smart cities could ensure the availability of various amenities and resources needed to make them thrive from financial, social and health perspective. Part III, *Durability*, discussed the factors that ensure societal well-being and development in a longer perspective.

5.2 Appeal

Undoubtedly, new technology will have many different uses for many different things. While some technologies may be invented for a specific purpose in mind, many others have been developed through an iterative trial-and-error process in which they do not come to their full potential before having passed an evolutionary process and having been tested in various forms for various purposes.

In terms of increasing the "appeal" of a smart city, this book springboards into a discussion of "attractiveness", what it is that actually attracts people to a specific smart city as opposed to any other one, and what expectations there are to be had following a pandemic. This section continues discussing the "labour market" in a smart city and how it could be affected following a pandemic, the possible scenarios and what approaches to take given the different possible outcomes. Finally, this section discusses "housing" and why it has come to be formed the way it has in smart cities, "smart homes", the challenges of housing construction, the problems with overcrowding and what to do to mitigate it in order to keep the spread of pandemics down.

Naturally, many of the aspects that make a city attractive to people in times outside of pandemics will also be valid factors even during the times when there are pandemics around. In short, this can be summarised as making opportunities more accessible and making society more transparent and credible. In concrete terms, this entails that adopting strategies and action plans while seeking out new means of collaboration will be instrumental features in increasing the appeal of future smart cities. The public sector will need to utilise Big Data, but in many cases, it has neither the means nor the competency to do so in an optimal manner. In fact, the data may be more effectively collected by other actors, such as by academia or consultancies etc., or by other companies or initiatives as a means of tracking pandemic spread. However, denizens will need to know how the data are utilised, and the data must have clearly defined purposes and the process must be fully transparent in order to win the confidence by the denizens. It is essential that the governing bodies do their utmost to prevent a scenario in which "big tech" companies (or any other organisational entities) are feared more by the people than the pandemic itself. It is also important that the cities' governing bodies are not too reticent in making investments aimed at future-proofing the city during the recovery periods following the pandemic. Failure to do so will likely cost many times more both in money and in lives the next time a pandemic, or disruption of similar magnitude, strikes.

In terms of the labour market, it is true that this is to a large extent controlled by the market. However, the governing bodies can provide for some arrangements to ensure the sustenance of the competence and skill within the cities. Failure to properly tend to the city's skilled denizens may lead to a "brain drain" and a loss of potential as they leave the city in search of better opportunities elsewhere. Procedures for setting up possibilities to work remotely (from one's home) will be essential for the professions in which this is possible, even after the pandemic has passed. Not only because it allows for more flexibility in people's regular working conditions, but also because there is a need to have a digital infrastructure and procedures set up so that they may quickly be set in action should another pandemic emerge. There will also be a need for clearer regulatory frameworks regarding different types of employment, such as "gig work". As the digital transformation progresses, so will the automation/substitution of labour. Perhaps even more so, and in a faster pace, using the pandemic, and the need for social distancing, as a pretext. Against this backdrop, there will be a need to build people's trust in the digital transformation and the substitution of labour. The apprehension of denizens should not be belittled or neglected. It is not merely a case of expecting denizens to resign to fait accompli, because a lack of trust in the processes and in the authorities will eventually lead to increased dissent, increased risk of the spread of dis/misinformation and a deepening of the digital divide where an increasing portion of the population is loathed to using digital technology. On that account, it is important to ensure that there is an adequate social safety net in place; especially for those workers faced with the risk of redundancy. To that end, there will be a sense of urgency for increased reskilling opportunities, particularly so for jobs based on routine-oriented tasks, as these will most likely become automated first.

In regard to housing, there will be a need to prepare smart homes for future technology. As such, there needs to be a "circular economy"-influenced mindset when designing the future smart homes. This means that the houses need to be designed in a way that it is possible to upgrade various modules as necessary without the need of making any fundamental reconstructions or extensive renovations of the houses. On a broader, urban level, the housing issue needs to be addressed inasmuch that there will be an increased need of different types of housing designs that reflects and accommodates for the actual way family units look like today and how they are projected to be for the foreseeable future. In doing so, one may alleviate some of the overcrowding problem that is currently plaguing so many cities around the world. At the same time, there is a need to ensure the availability of affordable housing. This is especially true in times of pandemics where people are more likely to make use of a "home office" and may need to procure homes with a room dedicated to this purpose.

Other measures aimed at reducing overcrowding include making better use of the suburbs that have the potential, or are already showing signs, of expanding. While crowd mitigation is a powerful instrument in combating the spread of pandemic viruses, having means of tracking pandemic data is another quintessential tool. For that reason, there is a need for authorities to harmonise the databases and digital systems used between the different government agencies so that it is possible to share datasets regarding potential areas that are particularly exposed, or likely to be jeopardised in the event of a viral outbreak.

As such, a city's "appeal" is contingent on the availability of opportunities to be had in spite of the curbing effects of the pandemic. Does the city proffer opportunities in finding jobs and housing, and does it in proximity to one another offer an environment that caters to the many needs of the denizens? According to a 2021 report by the Milken Institute, Provo-Orem, Utah was the larger city that succeeded best in this regard following the pandemic in 2021, whereas Idaho Falls, Idaho was the most successful smaller city (Galdamez, Kesteven, & Melaas, 2021). The key to success in Provo-Orem's case was that it was a recipient of the tech sector's out-migration from the expensive US West Coast. While the city holds a comparatively recent profile as an "innovation centre", it avails itself to offer a high quality of life and amenities. Located in the mountain region, it also holds significantly lower costs than Silicon Valley. Conversely, the success of Idaho Falls is in some part attributed to short-term job growth, but also to the presence of several high-tech industries as well as its advantageous location for various types of scientific research. In these cases, it is clear that the agglomeration effect set in motion by the tech industries was fruitful.

5.3 Facilities

In terms of a smart city's "facilities", this book has explored various aspects such as how a city can ensure the availability of various amenities and resources needed to make a city thrive financially, socially and healthwise.

Infrastructure and travel are essential to a city's "facilities". Undoubtedly, pandemics severely impact the manner in which we travel. It is true that during COVID-19, people travelled markedly less and that many business trips were substituted with digital conferences. At the same time, technological advancements constantly seek to improve means of travel, whether it is about expediting the travelling time, increasing capacity or becoming more energy efficient. A tricky aspect in regard to travel is that new technology needs, on the one hand, to account for people's actual needs. On the other hand, it also needs to look beyond people's expressed needs in order to develop means of transportations that benefits society in a way that the people may not have been aware of themselves at that point in time. A quote often (albeit tenuously) attributed to Henry Ford contended that: "If I had asked people what they wanted, they would have said faster horses" (Vlaskovits, 2011, para. 1). That is to say, the future modes of travel may involve new arrangements that can easily be deployed during pandemics. For instance, smaller electric aircrafts may provide some passengers with a less crowded travelling option for inter-city travel during pandemics. Further in the future, roadable aircrafts may also offer a solution for people looking to avoid both crowds and on-ground traffic congestion. However, closer in time, there needs to be a way to mitigate the pressure on the public transit systems by creating more seamless modes of travel wherein the points of contact with potentially unhygienic surfaces are reduced. Micromobility devices may also assist in reducing the number of people travelling during peak hours. Implementing intelligent transportation systems (ITS) can also assist in creating a more even and balanced traffic flow.

Health and welfare is another fundamental aspect of a smart city's facilities. In recent years, the focal point of the popular debate has been shifted from curative healthcare to pre-emptive wellness. While a pandemic most certainly places much focus on the curative aspects of healthcare, the pre-emptive wellness factors are part of the conversation as well, if not more so. The COVID-19 pandemic more than ever before stressed the need for people to take responsibility for the well-being of themselves and that of others, by observing social distancing, and isolation in the event of the slightest flu-like symptoms. A potential ripple effect is the sense of urgency for individuals to take command of other health aspects as well, such as smoking and obesity, since these are risk factors known to escalate the effects of COVID-19 (Monteiro et al., 2020). An aspect of facilitating this would be for authorities to consider a wider use of personal health records (PHR), which would allow individuals more personalised, pre-emptive care. Blockchain technology could be a valuable asset in terms of ensuring technical optimisation and patient confidentiality. Also, smart cities will need to deploy systems for health data tracking in order to track the progression and spread of the pandemic. This, in turn, necessitates that the data needs to become more interoperable with the various databases in which they are stored across different public agencies and/or public organisations.

Global hubs provide the smart cities with another integral component of its facilities. Global hubs ensure that the city remains financially viable while providing opportunities both for work and for commerce among the city's denizens. The ability for enterprises to reach out to customers even in times of pandemics and lockdowns will, in many cases, be a daunting challenge. In many cases, businesses will be resigned to rely more on their digital platforms in order to move units. In other cases, finding partners will be a way for new businesses to split the risk. For global hubs already set up before the pandemic eruption, there will need to be some publically orchestrated relief funds available for which these companies may apply. Priority should be given to organisations providing goods and services of considerable importance to society.

Essentially, a city's "facilities" are determined by the availability of resources that can enable the city to manage the hardships during and after a pandemic. Does the city show innovation and resilience in terms of providing transportation, healthcare/welfare and safeguarding international businesses? A report by the London-based analytical agency Deep Knowledge Analytics (DKA) (2021) concluded that the cities that achieve the highest score in this regard is Abu Dhabi, Singapore and Seoul.

Compared to other urban areas in the region, Abu Dhabi has benefited from its status as a smart city in regard to its pandemic preparedness (Al Hosany et al., 2021; Kakderi, Oikonomaki, & Papadaki, 2021). Its municipalities have consistently been improving the protection of public health and safety using various forms of digital technology. With their help, the United Arab Emirates in October 2020 became the very first country in the world to carry out more COVID-19 tests than the total number of its own population, 10 million tests to a population of 9.99 million (Al-Rifai et al., 2021; Suliman et al., 2021). Other technologies include technologies for crowd management, such as motion sensors and face recognition, aimed at detecting violations of COVID-19 measures in addition to tracking health standards compliance (Simić et al., 2020). Furthermore, the Abu Dhabi government has implemented the use of electronic wristbands to help identify and track patients' geographic location in order to ensure that the isolated individual does not leave their home or endanger public health (Alqarawy, 2021). By isolating potential travellers and "super spreaders", these measures aim to make the public transit safer to use. Nevertheless, a caveat that bears mentioning here, is that should one even contemplate introducing any such measures on a systematic and widespread level, the system needs to be subject to strict scrutiny under an independent "watch dog" agency, with clear and defined directives regarding the data that is collected, with respect to the individual integrity of the passengers.

By the same token, Singapore and Seoul have undoubtedly drawn lessons from past experiences with prior pandemics such as MERS, SARS and H1N1 and so forth (Sharifi & Khavarian-Garmsir, 2020). Moreover, these cities also immediately activated their "municipal emergency plan", which would enable a timely response to the pandemic. Hence, their public health systems were sufficiently stocked with primary healthcare resources and were able to maintain a strong sense of "facilities" by and large (Deep Knowledge

Analytics, 2021; Sharifi & Khavarian-Garmsir, 2020). These cities and countries faced less scarcity and would need to struggle less for resources such as personal protective wear, masks, test kits, laboratories, etc.

5.4 Durability

In exploring the "durability" of smart cities, this book has investigated how a smart city can make itself withstand both internal and external pressure and provide a city that is capable of tackling any and all possible events that would seek to challenge the very core of the city and its identity.

Digitalisation, for instance, aims to ensure that the city is able to keep up with technological challenges. Without modern, advanced digitalised technology, the city's identity as a "smart city" would be for naught. However, it is important to remember that technology progresses at a relatively slow pace before it can be implemented in practice. This is not only due to the development cycles of the technology itself, but also considering various regulatory and legal processing of new technologies that need to pass before they can be put to use. For that reason, it is important that strategies relating digitalisation take a long view and that investments aimed at developing technology that can improve the sustenance of the cities during pandemics are made well ahead of time. As the technologies utilising virtual reality (VR) and augmented reality (AR) continue to improve, their application will see a wider use for a variety of areas. For this reason, it is important that there is adequate bandwidth and Internet infrastructure in place to support the use of these technologies in the near future, as they become more advanced and consume more bandwidth.

Safety and security, on the other hand, seeks to safeguard a city's physical and digital security. In this regard, smart cities will need to employ new and cybersecure technologies as well as new approaches in order to ensure that law enforcement keeps one step ahead of crime. In order to do this, there needs to be a more widespread use of safety measures for online crimes, such as improved multi-factor authentication and natural language processing. For "offline" crimes, autobots may present an additional tool to help counteract crime, in addition to various types of "weartech" and mobile application software. Increasing collaboration through public–private partnerships may be a way for cities to secure the resources and competency needed.

Finally, sustainability seeks to reconcile the rapid pace of urban transformations with the slow pace of environmental resource renewal. Sustainability is essential to a city because a city with poor sustainability will in all likelihood suffer from either stagnation or atrophy, both in population numbers but also in living standards. This book sought to investigate sustainability from the premise of the United Nations' "Sustainable Development Goal: 11 (SDG 11)", of which some were applicable for smart cities. However, it should be noted that the broader SDG definition of "sustainability" is a considerably more eclectic term that encompasses many different areas that lie far beyond the remit for a debate on smart cities. This book looked at (1) the protection of the world's cultural and natural heritage; (2) the reduction of adverse effects of natural disasters; and (3) the reduction of environmental impacts of cities.

In achieving sustainability, cities need to ensure the protection of cultural and natural heritage by creating a more harmonised and transparent way of estimating their value, popularity and indeed, what should be counted as a "cultural" and/or "natural heritage". Also, in the future, cities could take a more active part in providing relief funds aimed at supporting local talents. Designing buildings intended for public events, such as arenas, malls etc. would, in the future, be designed with greater pandemic consideration, meaning that it will be easier to isolate visitors from one another as well as from potential performers/presenters/guides etc. Existing venues would need to be redesigned (or at least be prepared for swift refurbishing if necessary) in order to ensure adequate social distancing while also ensuring that the places and events remain open and operational throughout the pandemic. More events may also become available in digital formats as VR and AR becomes more advanced, enhancing the experience from a safe distance. The deployment of digital twin cities in more cities will be paramount in order to more accurately analyse how pandemics and potential natural disasters affect different parts of a city and to assess which areas are impacted the most. Such may, in some cases, be set up as a collaborative endeavour involving both the city and other actors in, for instance, academia.

Combating detrimental environmental disruptors is also of key importance. Outdoor and indoor air purifiers may be installed to reduce air pollution in some of the worst affected areas in a city, since air pollution is known to worsen the effects of certain pandemics, such as COVID-19 (Bourdrel, Annesi-Maesano, Alahmad, Maesano, & Bind, 2021). While single-use items such as health/hygiene-related products like face masks, plastic gloves etc., are instrumental to certain aspects when combating pandemics, adopting circular solutions would serve to reduce much of the waste-related problems that future technologies may bring forth. Examples of this include components used in solar panels and wind power blades, to name a few. While this is not an overbearing problem at the present moment, it may be in the future as these technologies expand and eventually start to break down with time.

Also, the issue of energy supply will need to be discussed more extensively. There needs to be enough energy to supply the ever-growing technology and expanding cities, while at the same time the energy needs to be as clean as possible as to not cause further air pollution, which may, in turn, worsen the effects of the pandemic. Presently, no single source of clean energy can generate enough energy to fully replace the non-renewable energy sources. For this reason, there needs to be a mixed-energy solution that involves many different types of energy sources, with the ambition of reducing the use of non-renewable, pollution-generating types of energy sources as much as possible.

The "durability" of a city is conditioned by its ability to withstand pressure and/or challenge. This entails that the city must have the technological amenities, and also that the city is safe and sustainable in order for the population to thrive in the city. In three separate reports, Copenhagen is the only city ranked among the top 10 smart cities considered to be the safest, the most digitalised and the most sustainable cities in the world (Cassells, 2021; IMD, 2020; Kielstra, 2021). There are a number of keys to Copenhagen's success. Copenhagen has a well-developed digital infrastructure and has for many years been considered to be one of the "smartest" cities in the world (Bernardo, 2019). In keeping the crime rates low, Copenhagen has focussed much on intervention with preventive initiatives, much thanks to the use of extensive data (Kielstra, 2021). In regard to sustainability, Copenhagen made early progress in areas such as traffic electrification and in increasing the use of renewable energy sources (Šlogar, Bandov, & Čakanić, 2020). However, some critics have argued that Copenhagen has adopted a strategy for climate neutrality based on externalisation. This means that only emissions produced locally are counted while emissions produced outside of the city for products and services consumed locally remain high (Krähmer, 2021). This suggests room for improving the smart city strategies of sustainable urban development in general, even for those cities that would normally score high on various sustainability indices.

6 Concluding Remarks

Technological advancement is constant and never completely static. The metropandemic revolution seeks to empower cities during and after a pandemic through the use of advanced digital technology. In this, the aim of this chapter was to investigate how smart cities can build cohesion based on the lessons learned throughout the chapters of this book, and thus set the metropandemic revolution in motion. In synthesising the themes and overall results covered in this volume, it can be concluded that the digital transformation will most certainly play a central role in future post-pandemic urban development.

Given how fast a pandemic can spread, and how far it can reach, it is imperative that cities secure a pandemic response that allows the societal functions to continue operating while keeping the population safe and the viral spread down. The digital transformation that will make this possible, along with the metropandemic revolution that follows, cannot be ignored. It behoves the policymakers to take responsibility to keep abreast of changes in the ongoing digital developments and inventions as they occur, and respond in a pre-emptive manner. Furthermore, national governments will need to bestow a greater sense of agency to the cities and their ability to combat the pandemic. Ultimately, the pathway towards empowering the cities, and achieving cohesion between the three overarching themes explored in this book, is a process in which governance, digital technology and the need of the city's denizens must work in tandem. As the metropandemic revolution is upon us, the time has come for a more widespread debate on the future of urban planning, what direction our smart cities should take and how we may ensure pandemic resilience among our cities.

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Afterword

Lessons for Our Future Cities

Carlo Ratti

Following the first eruption of the COVID-19 virus in early 2020, some observers eagerly declared that cities were finished. People – so the story went – would relocate en masse to less dense locations, such as coastal villages and mountain hideouts, leaving congested urban centres deserted. Is this a valid theory?

I do not think so. Despite the devastating loss of lives and financial resources, cities will be back stronger than ever. After all, they have survived multiple disastrous pandemics throughout millennia of their history and have always managed to resurrect. Look at Venice: 60% of its inhabitants died during the Black Death in the fourteenth century, but it took just a few decades for the city to recover. People quickly went back to crowding its small "calli" and "campi" – the backbone of an urban centre widely admired across the world.

That said, even if COVID-19 did not destroy our cities, it did not leave them unscathed. How will the urban space change after the pandemic, then? Anthony Larsson and Andreas Hatzigeorgiou have, in this thoughtful book, invited us to contemplate in what ways our cities can come back stronger and more liveable after a long health emergency. They thoroughly review the challenges faced by different stakeholders – public officials, entrepreneurs, scholars and the general public – and assess their conclusions at the end of each chapter. After reading their work, I believe we can draw two overall conclusions regarding the future of our cities.

The first conclusion is that, more than significantly altering the urban hardware, COVID-19 will probably leave a lasting legacy on behavioural changes. Different transitions that were already taking shape before the viral eruption have been accelerated and are having a major impact on our daily lives. Take, for instance, the mixed regime of remote and in-office working. With commuting becoming more flexible, taking place across different hours of the day, much pressure could be lifted from our road infrastructure. Moreover, as micro-mobility like shared bikes and electric scooters is becoming more widely adopted, traffic congestion could be further reduced, leading to better air quality.

Looking beyond individual solutions, the second conclusion I would like to propose deals with the importance of developing the right method to design the city of tomorrow. In this sense, I am impressed by the pace at which actions have been put in place in cities over the last few years. Faced with highly unpredictable scenarios, municipalities could not follow any script but had to be bold and quick in order to address the shifting needs of their communities. Experimental initiatives ranging from pedestrianisation to affordable housing and dynamic zoning have been conceived and implemented at a markedly fast pace. In other words, far from rendering cities obsolete, the pandemic has unlocked an ever-broader potential for innovation – what the economist Joseph Schumpeter famously called "creative destruction", though at an urban scale.

Such a method for urban innovation entails a trial-and-error approach. The more attempts we make, the more likely we might find successful solutions. Moreover, such an approach – which is reminiscent of natural evolution – is centred upon feedback loops and requires citizens to voice their opinions and help collectively shape the places in which they live.

Clearly, some of the efforts implemented in response to the pandemic will fare better than others. That is why it is so important to keep committing to a broad range of projects and urban experiments even after health emergency finishes. With participatory digital platforms in place, people's opinions and suggestions could be consolidated to help guide urban changes. As Larsson and Hatzigeorgiou remind us, only an agile and inclusive approach to urban innovation can help our cities as they recover from the COVID-19 pandemic – and help build long-term resilience.

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Index

Note: **Bold** page numbers refer to tables and *italic* page numbers refer to figures.