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Upgrading a city via technology

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ABSTRACT

As cities become the pillars of economic production, operating them by using the latest technology takes center stage. This introduction to a special issue on the "city and technology" reviews one of the developing areas in making cities more efficient and effective via using technology as part of a whole system. Invited authors presented their research in fourteen articles on the effect of technology vis-à-vis the functioning of cities as a system. They examine the opportunities and challenges presented by the integration of technology in various aspects of operating a city.

1. Introduction

A well-established fact holds true even more today: Most of world's economic production is provided by cities. Hence, the ever-present competition among cities for skilled people, cheap resources, etc. is intensified [1]. The need for upgrading cities to obtain or keep a competitive edge is more apparent than ever [2–4]. The leaders of cities are proud to be on top of city-ranking indexes [5,6]. People are drawn to cities in the top of these lists in order to participate in the sought-after economic and social life. Leading companies and banks prefer to be placed in global cities [7]. This interest increases real estate prices in these cities as well as the wealth of their residents.

There is not a consensus among academicians on a ranking methodology of city competitiveness level, however, most of the ranking methodologies include a technology component employed in a city directly or indirectly [8–13]. Therefore, city-ranking indexes give us feedback regarding the level of technological advancement of a city compared to other cities. In what follows, we used "upgrading" synonymously with "attaining higher levels in these rankings". We believe this approach brings a clarification to the word "upgrading" used extensively in this special issue.

Upgrading cities via technology is a newly developing market for various ICT and consultancy companies. IBM's "smart city", Siemens' "city of the future" and Cisco's "connected cities" are some of the companies active in this market along with their respective marketing slogans. Although these companies are mature in their major business lines, their city–technology related products are in their infancy. These companies are expected to divert much more of their resources to these products in the near future.

In addition to private companies, an increasing number of academics from various disciplines, including economics, engineering, regional planning, and strategy related fields are showing interest in the challenging problems and revelations arising from the relation between cities and technology. In particular, transportation, health, and utilities are examined extensively in the literature. The subsystems of cities are one of the topics that have not been elaborated as much [14]. We know efficient and effective working subsystems are crucial for a healthy system. Therefore, improving the subsystems of cities is vital for their effectiveness. Cities that realize the importance of technology and apply new technology in related subsystems gain a competitive advantage over those that lag behind. An inefficient transportation system can cost a resident an average of two or more hours per day. Conversely, an efficient online tax collecting system supported by an effective database may provide advantages both to the administrators of a city and to the entrepreneurs who are invaluable for its livelihood. It is

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undeniable that the daily activities of the residents of a city are directly linked to the level of technology the city employs.

Even though the pace of radical technological innovation seems exceeded by the pace of social change [15], leaders of top ranking cities are very interested in catching up with the latest technologies to facilitate the best social atmosphere for their citizens. The benefits from integration of technology in various aspects of operating a city are evident in most cases so leaders do not hesitate to use technology as a promotion tool. Every day we read or hear news about cities adopting different components of technology. Officials proudly declare events such as crime rates dropping after the installation of face recognition software or new traffic management software reducing traffic. As a result, developments in technology find specific applications in various areas in city subsystems: GPS technologies bring ease to navigating a city also making freight transportation more efficient [16], database technologies provide opportunities for health tracking systems [17], pattern recognition software creates new opportunities for security systems [18,19], and mobile technologies are indispensable for individuals participating in social activities taking place in a city [20].

1.1. Upgrading a city on waves of technology

The technology and city connection can be examined in three waves along the lines of the approach developed by Toffler [21]. The first wave is the use of technology in the infrastructure of a city. This corresponds to a period when transportation, utility distribution, waste collection, water distribution, [22] and similar infrastructure were becoming available for residents of cities. As a result of this wave, cities became places that could accommodate larger populations. City residents started to benefit from well-established utilities that were not readily available in rural areas.

Today, nobody thinks of a city without power or water distribution infrastructure. Roads are the blood vessels of cities. Likewise, gas distribution networks, waste and sewage collection systems became ordinary amenities for residents of most cities.

The second wave is the application of ICT in various subsystems of cities. Subsystems such as traffic, electricity distribution, and waste collection became “smart” with ICT technologies. The second wave provided efficiency and effectiveness to city subsystems. The so-called “smart cities” or “intelligent cities” refer to those cities that advanced by applying ICT to city subsystems [23]. For example, by using appropriate hardware (sensors, wireless equipment etc.) and software (artificial intelligence, expert systems etc.) traffic lights manage traffic in an optimal way without the need of any human intervention. Similarly, it is nearly impossible for a criminal activity taking place in a public space to go undetected. Surveillance cameras are more ubiquitous than ever. The footage provided by these cameras together with software using pattern recognition algorithms can easily identify criminals.

Today, we are living in the second wave. ICT applications are increasing all over the world. Hence, the second wave brings more efficiency and effectiveness to cities. Running a metropolitan area became more manageable with the help of real time data collection and processing. Expert systems can evaluate data and make real-time decisions without any human interaction. Leading technology companies make huge profits from this newly emerging market.

The third wave refers to establishing a fully self-sustaining city, an idea – at least for academicians who work in engineering and urban planning areas – that has not yet reached its full potential [24–26]. Futurists are discussing the various forms a self-sustaining city can take. Companies that are active in technological applications for cities also search for the products that would be marketable in the quest for a self-sustaining city. Experts are discussing the ways in which a zero-waste city is possible. Attaining zero carbon emissions is also a part of zero-waste ideal. Transportation infrastructure and energy production technologies need to be revolutionized in a self-sustaining city. Thus, the essential elements of a self-sustaining city such as water sustainability and renewable energy are active research areas attracting experts both from academia and the private sector. Solar and wind energy are the most popular renewable research areas for the future of cities. As a result, a city in the third wave will not only use the latest Information Communication Technologies but also other advanced technological developments in renewable energy, public transportation, waste recycling, water management etc. Hence a city in the third wave will be a fully self-sustaining city.

1.2. Quest for ideal city

Throughout history, man has been searching for an ideal place to live. Thomas More's Utopia is one of the most popular examples of this quest [27]. In Utopia, More focuses mostly on citizens and their relations among themselves. Technology does not strike More as a major concern. However, remarkable advancements in the recent decades made technological aptness as much a component of a model place to live as social and political ideals. Besides, governments and companies do not resist technological changes as much as they do to social or political ones.

Most of the recent projects towards upgrading cities can be grouped under the second wave, ICT embedded infrastructure upgrades. New city designs are getting more popular in different parts of the world. Masdar City in UAE, a significant new city design initiative [28] and Songdo, a smart city that is being built as an international business district, 40 miles southwest of Seoul in South Korea are only two of the examples of these new initiatives [29,30].

Technology is the application of knowledge to the practical aims of human life. Technology includes the use of materials, tools, techniques, and sources of power to make life easier and more pleasant, as well as more efficient and more productive [31]. In this special issue, we cover a broad range of such applications within the context of designing, upgrading, and operating a city. Information Communication is one of the most popular application areas. We especially focus on algorithm embedded Technologies in this issue. These Technologies mainly bring the “smart” component to a city. Moreover, applications of a wide variety of mathematical models in upgrading various subsystems of the cities are examined. In selecting examples of applications of scientific knowledge to practical problems we gave priority to the examples particularly suited for upgrading cities.

The examples collected in this issue demonstrate there are potential threats as well as opportunities for cities in the future. Threats can mainly come from security issues, while potential opportunities abound in the form of efficiency and effectiveness in health, education, production etc. For preventing threats and realizing opportunities, managerial and social awareness as well as economic support are imperative. Within this framework, we strongly believe the implementation of the latest technologies will fuel the successful upgrading of cities. Therefore, this special issue focuses on the relationship between a city and technology. Obviously, it is not possible to include every aspect of this vast area in this issue. Nonetheless, in selecting articles, we put an emphasis on both capturing the big picture as well as presenting specific applications and cases that will deepen our understanding of this relationship.

1.3. Special issue

There are fourteen articles selected for this special issue. These articles are grouped into two: Theoretical articles discuss the city–technology relation in conceptual terms whereas application articles present and analyze various cases from all over the world. Some articles focus on only one subsystem of a city, while others consider multiple subsystems simultaneously.

The opening paper by Tolga Akcura and Burcu Avcı examines the relation between Information Communication Technologies and macro variables in global cities. The authors identify the significant country-level factors contributing to creating global cities and suggest important areas where and how ICT could make an impact. The study focuses on the importance of central and local government cooperation in order to form globally successful cities. Findings of the study have implications for governors, mayors, and technology managers at a local and national level.

Junghoon Lee et al. study the process of building an effective smart city. The authors develop a framework for conducting case studies taking San Francisco and Seoul Metropolitan City as examples of smart city implementation. The study's empirical results suggest effective and sustainable smart cities emerge as a result of dynamic processes in which public and private sector actors coordinate their activities and resources on an open innovation platform. Authors point to eight "stylized facts" based on both quantitative and qualitative empirical results that underlie the facilitation of an effective smart city. The paper offers useful insights to managers seeking the implementation of smart city developmental projects.

The principal premise of a "ubiquitous-eco-city" is to provide a high quality of life to its residents, workers, and visitors with low-to-no negative impact on the natural environment using state-of-the-art technologies in planning, development, and management. The paper of Tan Yigitcanlar and Sang-Ho Lee aims to put this premise to test and address whether u-eco-city is a dazzling smart and sustainable urban form constituting an ideal 21st century city model or just a branding hoax. The study explores the recent developments and trends in ubiquitous technologies, infrastructures, services, and management systems and their uses and implications for the development of u-eco-cities. In particular, the study takes a closer look at the Korean u-eco-city initiative and critically discusses its prospects in forming a smart and sustainable urban form towards an ideal city model.

Timo von Wirth et al. put scenario analysis to work within the context of urban development. The authors construct scenarios for the Limmattal region, a suburban agglomeration close to Zurich, Switzerland. The study demonstrates a functional structure for science–practice collaboration leading to four different scenarios for 2030. Analyses of regional system dynamics reveal the most important feedback loop among five impact factors within the region. This provides a better understanding of the systemic interactions in regional transformations. The development of regional scenarios, including analyses of feedback loops, shows the potential to support knowledge integration in research processes involving science and practice.

Timothy Dixon et al. present research findings from the EPSRC Retrofit 2050 project, and analyze the relationship between technology roadmaps and transitions theory literature, discerning the research gaps at a city level. The paper develops a research methodology to describe the development of three guiding visions for city regional retrofit futures and identifies key sustaining and disruptive technologies at a city scale within these visions using foresight techniques. Findings of the study have implications for regional planners and top-level urban decision makers.

Johanna Ylipulli et al. examine the operating process of two public computing infrastructures in Oulu, Finland. These are a municipal Wi-Fi network and large interactive displays. The authors analyze the adoption of these technologies in public urban places with a conceptual technology appropriation model contributing to the adoption or rejection of a technology. Qualitative data of the study reveal the adoption of displays is hindered by their questionable utility and people's concerns about interacting with displays in a public social setting. Findings of the study identify issues that designers should take into account when locating these technologies in urban spaces in the future.

Sheila U Appel et al. apply techniques from machine learning and data mining to determine the future vacancy risks for individual properties and for neighborhoods within the sociotechnical system of Syracuse, New York. The authors claim these predictive analytics allow a city to move from decision-making based on 'educated anecdotes' and reactive strategies aimed at the most urgent needs, to policy development based on informed, holistic insight and proactive interventions that prevent and reverse decline. The model developed in the study may be applied to various declining cities in the world.

Marcin Kulawiak and Zbigniew Lubniewski present a model for analysis of critical infrastructures in cities. The system offers integrated tools for target analysis, hazard scenario simulations and spatial analysis within a remotely accessible web-based geographic information system. The model has been applied to research conducted in Gdansk with the aid of blast attack, chemical leakage, and flood hazard scenarios, as well as a spatial density algorithm, which highlights events in which the proximity of infrastructures influences their susceptibility to a single attack. The paper also discusses the way in which the tools provided by the system aim to assist in the processes of infrastructure vulnerability assessment, mitigating discovered risks as well as strategic planning of city development.

Anil Namdeo et al. present a geospatial modeling approach, exploring the potentials for deployment of publicly accessible charging opportunities for consumers. The modeling approach was applied through a case study, which combines census statistics indicating lifestyle trends, family size, age group, and affordability with travel patterns for an administrative region in the northeast England. Three categories of potential plug-in electric vehicle (PEV) users have been identified: "new urban colonists", "city adventurers", and "corporate chieftains". Results of the study indicate that corporate chieftains, primarily residing in peri-urban locations, with multi-car ownership and availability of onsite overnight charging facilities form the strongest group of early adopters. On the other hand, new urban colonists and city adventurers, primarily residing in the inner-city regions, show potentials of forming a relatively bigger cohort of early PEV adopters, but their uptake is found to be dependent largely on public charging facilities. Findings suggest effective PEV diffusion in city-regions globally would require catering mainly to the demands of the latter group, focusing on development of a purpose-built public charging infrastructure, both for provision of on-street overnight charging facilities in residential locations and for fast charging at parking hubs.

Alexander Spickermann et al. argue the socio-technical system of multimodal mobility has the potential to solve some of today's urban mobility challenges. Multimodal mobility combines both private and public transport modes, thereby capitalizing on the benefits of various systems. Realizing mobility systems are non-monolithic and transitions require interdisciplinary analyses, the authors adopt a multi-level perspective with actors across different fields. The study draws on empirical evidence from three parallel Delphi studies and several focus group workshops to present strategic implications to firms, public authorities, and customers. The paper aims to guide cities in developing a long-term future vision of urban mobility systems in Germany while employing elements from the transition theory.

Carolin Spalteholz and Scott G. Dacko present their research regarding the shifting of city travelers' behaviors to intermodal travel. The extant literature, data from government and industry sources along with extensive qualitative primary data from in-depth expert interviews and city traveler interviews are then drawn upon, analyzed, and discussed in terms of policy and implementation considerations. Among the findings is the identified need for collaboration among mobility service providers to reduce perceived mode barriers and provide transparent information. Moreover, policy makers will need to focus on attractive incentives rather than on coercion mechanisms in order to sustainably motivate intermodal traveling. Tailoring the interventions and communications to different city inhabitant segments will also be key to policy effectiveness. The study finds substantial support for the introduction of an online integrated, intermodal information platform.

Soft-Computing techniques can assist in decision-making processes in the efforts of making cities more sustainable and better places to live. Sancho Salcedo-Sanz et al. discuss the application of Soft-Computing techniques to solve real time traffic problems. The authors focus on one of these problems, Reconfiguration One-Way Traffic Optimization Problem (ROWTOP). The problem consists of optimizing the directions of one-way streets in a city and reconfiguring them in the appearance of a major difficulty involving prolonged street cuts. The problem is defined as a multi-objective optimization case and is solved by using a Soft-Computing (SC) approach based on an evolutionary algorithm. Performance of approach is discussed in a real problem in a Spanish city. Findings show excellent results and prove the feasibility of these techniques as an innovative technology-based approach that may result in upgrading cities without incurring exorbitant expenditures.

Traffic Incident Management (IM) became an advanced new tool to reduce and prevent congestion on roads, especially in urban areas. IM involves the coordinated interactions of many public and private actors. To support these tasks in an effective way, advanced information systems are becoming increasingly important. John Steenbruggen et al. offer a broad overview of the principles and practices of Incident Management, with a particular reference to a Dutch example. The study aims to provide an empirical analysis of the critical success conditions for effective Incident Management in the Netherlands based on an online survey questionnaire administered among stakeholders.

The closing article of Sotirios Paroutis et al. examines how a company benefits by using the potential business of upgrading city via technology during recessionary times. Authors investigate whether smart city technologies can be considered as a strategic option for firms, especially in recessionary conditions. Prior smart city studies focus on the nature and impact of technological systems adopted in the context of particular urban conditions. Studies about recessions examine primarily their reasons and consequences. Currently, there is no research examining the role of city technologies as a strategic option for firms in a recessionary environment. To address this gap, the authors develop a conceptual framework drawing on the earlier studies of recessions and examine the case study of the IBM Smarter Cities initiative within this framework. The study can be very well considered as a contribution to organizational change literature as well as strategic management literature.

I am indebted to a number of people who helped bring this project to fruition. I am deeply grateful to Fred Phillips, editor of the Technological Forecasting and Social Change, for providing me with the opportunity to edit this issue. I am indebted to the reviewers for their useful suggestions and critical remarks. Finally, I would like to thank the authors for providing us with stimulating and insightful papers. I think the fourteen papers included in this special issue address some of the most important issues regarding city–technology relationship. However, I also think they constitute only a start, their insightfulness notwithstanding. Undeniably, more research is required to fully understand the challenges regarding city upgrading and technology relation. I hope the articles in this special issue provide a foundation for future research on this important issue.

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