How "Smart" are Japanese Cities? An Empirical Investigation of Infrastructures and Governmental Programs in Tokyo, Yokohama, Osaka and Kyoto

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Abstract

Can cities be smart? In this article we define what a smart city is and formulate categories and indicators of smart and/or informational cities. Based on these measures, we investigate four Japanese cities as case studies that appear to be highly developed modern metropolises. We focus on infrastructures essential for an informational city as base for a ubiquitous, smart (in a narrow sense), creative, and knowledge city. We measure the level of "smartness" or "informativeness" for each city and create a ranking. Finally, as essential preconditions for a successful development of smart cities, we present political initiatives in Japan.

1. Introduction

Many cities in the world propose to be smart. However, what does the concept of a smart city really mean? What are the concrete criteria or indicators for smartness? Is it possible to empirically measure the degree of smartness? Based on such methods, is it possible to compare cities and to create rankings? Are there any political initiatives to enhance cities' smartness? In our case study on Japanese cities we are going to answer these questions.

2. Defining "Smart City"

"Smart city" is a rather fuzzy concept [34]. Nowadays, it seems to be a hype word, which is broadly used in popular science, in politics, and company-driven initiatives such as the *Smarter Planet Initiative* (IBM) or the *Smart+Connected Communities* (CISCO) [18]. But is there a city that does not want to be labeled "smart?" This leads Hollands [24] to ask, "Will the real smart city please stand up?" In some scientific studies, definitions or approaches of "smart city" are collected [e.g., 10;34;35]. All definitions stress the importance of information and communication technology (ICT) for the 21st century city [4]. In addition to it, we can find two different concepts of the smartness of cities, one in a narrow sense of the concept and the other in a much broader sense.

According to Chourabi et al. [10], it is possible to conceptualize a smart city "as an icon of a sustainable and livable city." In the "vision of a smart city", Hall et al. [23] introduce urban centers of the future, which "secure environmentally green." Here, a smart city is "forward-looking on the environmental front" [10]. This narrow concept of "smartness" is strongly linked to natural resources and energy, transport and mobility, buildings, and living conditions [35], in short, to the green, sustainable and livable city.

Giffinger et al. [19] define smart cities far broader by an enumeration of essential "characteristics," i.e. smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. Such a broad view of smart cities is anticipated by Castells [6] as early as 1989. He calls such prototypical cities of the network society [7;8;9] "informational cities." In the network society, as in informational cities, two spaces exist side by side: geographical space ("space of places") and the space of information, money and power streams ("space of flows") created via digital networks. In informational cities (or smart cities in the broader sense) the space of flows outperforms the space of places. The concept of *informational city* includes the narrower concept of the *smart (green) city*.

Concerning the geographical space, it is important *not* to refer to administrative borders, but—following the world city research [22;17;38]—to regions defined by dense patterns of interaction.

Research on smart cities (in the broad definition) "has so far received limited attention by academic empirical researchers" [35]. In our project on informational cities [43], we meet this challenge and study empirically (more than 30) informational world cities [31;32;33], seven cities in the Gulf Region, the ubiquitous cities of Songdo (Korea) and Oulu (Finland) [39] as well as four cities in Japan [14]. In this article, we report on the infrastructures and governmental

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programs to enhance the cities' smartness of the informational cities in Japan.

3. The case study: Japanese cities

In this case study we focus on four Japanese cities—Tokyo, Yokohama, Kyoto and Osaka. Japan used to be, and still is, an economically strong and highly developed country. Therefore, we can assume that cities we investigate are also competitive in many aspects. Tokyo is the capital of Japan, and a global city [38]. Yokohama is the second biggest city in Japan, and an important venue for business conferences. Osaka is the western counterpart for Tokyo, and as well economically significant. Kyoto is the former capital and economic center of Japan. Our choice of these four cities is based on these facts, as well as further indicators for diverse advanced infrastructures (creative, ubiquitous, smart, and knowledge) given in the city.

4. Method

To describe and analyze infrastructures of informational cities adequately, we apply a theoretical framework, which includes four different aspects of informativeness (Figure 1): (I) the *smart city* ("smart" in the narrow sense) is based upon "green" infrastructure, which is the application of ICT and other intelligent techniques on sustainability with the aim of a livable and green city; (II) in a *ubiquitous city* [41], ubiquitous computing is realized on city-level so that information is omnipresent and everyone should be able to create and to retrieve information whenever and wherever a need arises; (III) the *creative city* [16] is in need of certain infrastructures including creative clusters, theaters and creative neighborhoods; (IV) finally the *knowledge city* [5] is build upon infrastructures such as universities, knowledge parks and other research and development institutions.

The development of a smart city (in the broad sense) "entails the interaction of technological components with political and institutional components" [10]. Thus we have to analyze not only the cities' infrastructures, but political smart city programs as well.

In order to gather and analyze needed data, we turned to diverse methods. We performed an ethnographic field study in Japan enabling us to experience everyday life in the investigated cities, and to conduct semi-standardized interviews with people living and working there. Also, we used official statistics (published by the cities or bureaus of statistics) and conducted desktop research (for political initiatives, bibliometrics and patentometrics). According to Glaser and Strauss [20], all these methods are essential for formulating a grounded theory (i.e. theory grounded on empirical evidence). Their concept of grounded theory method is appropriate for new and emerging research areas (like the present case).

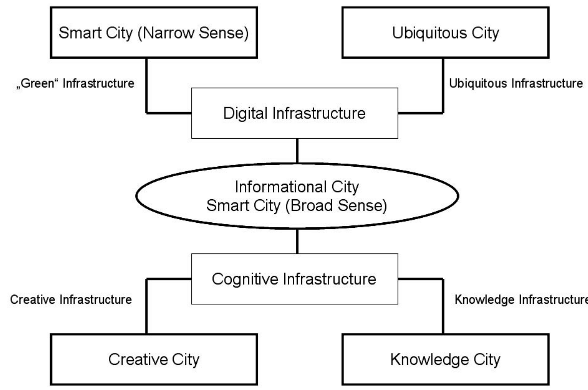

Figure 1. Infrastructures of Informational Cities

5. Results

In this section we present the results of our analysis of the exemplary cities as guided by the questions formulated in the introduction.

5.1. Informational infrastructures in Japanese cities

The infrastructures we consider to enhance cities' informativeness (or smartness in the broad sense) are the ones of a ubiquitous city (i.e. availability of ICTs), the smart city in the narrow sense (in terms of smart mobility, i.e. transportation, and smart environment), knowledge and creative city (in terms of smart living).

5.1.1. Ubiquitous city. Nowadays, the high-speed communication networks are indispensable, and therefore, the measurement of development in information and communication technologies became very important [29]. Almost all people on earth live within reach of a mobile phone signal. However, this does not mean all of these people have mobile phones, or that all these networks are upgraded to the 3G-technology [29]. Therefore, there is need for indicators of an advanced ICT infrastructure.

Broadband can be defined as technology enabling high-speed data transfer, and is indivisibly connected to the development of the Internet. Broadband became a key priority of the 21st century. It is also assumed, that its power will enable for economic and social growth, as it creates an environment nurturing the technological and service innovation. The development of broadband technology across business enterprises improves productivity, because it facilitates the utility of more efficient business processes. Furthermore, the new technology accelerates innovation by introducing new consumer applications and services [28]. "Broadband facilitates innovation, entrepreneurship, and productivity. Countries with 80% broadband penetration are more than twice as innovative as countries with 40% penetration" [13]. Very important are the universality and affordability, as it ensures that the broadband is inclusive and can be utilized in public services (like health, education or social integration) [13].

There are various approaches and indices to quantify the quality of ICT development in a country/city. One example is the IDI (ICT Development Index), which combines 11 indicators and compares the ICT development across countries. The three measured categories are: (1) *ICT access*, with such indicators as (a) the fixed-telephone subscriptions per 100 inhabitants, (b) mobile-cellular phone subscriptions per 100 inhabitants, or (c) percentage of households with Internet access; (2) *ICT use*, measured e.g. by the (d) percentage of individuals using the Internet, or (e) the amount of wireless broadband subscriptions; (3) *ICT skills*, with such indicators as (f) adult literacy rate, or (g) secondary gross enrolment ratio. In this IDI-ranking Japan took 8th place in the year 2011, and the 11th in 2012 [29]. Another index is the Networked Readiness Index, and as for 2013 Japan took the 21st rank. The Networked Readiness Index is based upon four core areas: (1) *environment*, e.g. political and regulatory, business and innovation; (2) *readiness*, e.g. infrastructure and digital content, affordability, skills; (3) *usage*, e.g. individual, business and government, and (4) *impact* (economic and social one) [2].

Some further indicators were used in the Data Book on Information and Communication Technology 2012 [45], were the sector performance in Japan in 2010 was as follows: (1) regarding the *access*, there were 31.9 fixed-telephone subscriptions, 95.4 mobile phone subscriptions and 26.91 fixed (wired)-broadband subscriptions per 100 inhabitants, also, 83.4 % of the households had a computer, and 81.3% had an Internet access; (2) *usage* was measured e.g. by the international voice traffic, the domestic mobile traffic, or individuals using the Internet (78.2%); (3) *quality* was quantified by the population covered by a mobile-cellular network, and as for Japan it is 100%; (4) *affordability* concerned the telephone, mobile phone and (fixed) broadband sub-basked ($26.4, $55.9, and $23.1 per month, respectively); further categories were (5) *trade*, as the import/export of ICT goods or services export, and (6) *applications*, concerning e-Government, or secure Internet servers (743.3 per million people) [45].

Another index is the Booz & Company's Digitization Index. It calculates country's digitization using 23 indicators to measure the following six core attributes: (1) *ubiquity*, i.e. extent to which consumers and enterprises have access to digital services and applications; (2) *affordability*, i.e. extent to which digital services are priced in a range making them available to as many people as possible; (3) *reliability*, i.e. the quality of digital services; (4) *speed*, i.e. the extent to which digital services can be accessed in real-time; (5) *usability*, i.e. ease of use of digital services etc., and finally (6) *skill*, i.e. the ability of users to incorporate these digital services into their lives or businesses [37].

As we can see, there are already many indicators defined, which are supposed to quantify the development of ICT (i.e. digital) infrastructure in countries and/or cities. In our case study we use some of these indicators. However, few of them cannot be implemented at city level, or are, in case of Japanese cities, irrelevant (i.e. the population covered by the mobile-cellular network, because the result is 100%). Also, we had to narrow the indices to data that is actually available to us. Eventually, we investigated following points in terms of the *ICT infrastructure:* (1) ISDN subscribers, (2) broadband cable TV (CATV) subscribers, (3) broadband DSL subscribers, (4) FTTH (fiber to the home) subscribers, (5) BWA (broadband wireless access) subscribers, (6) mobile cellular phone subscribers (all per 10,000 inhabitants), and (7) free WiFi Hotspots in the city.

The results show that Osaka's ubiquitous infrastructure is most advanced, as for the year 2011 the city had the most broadband CATV, DSL, FTTH as well as mobile phone subscribers. Tokyo took the second place with the most BWA subscribers and free WiFi hotspots in the city. Yokohama's performance was satisfactory; the city had the second best performance in terms of CATV, DSL and FTTH subscribers. Kyoto's performance was the weakest of the four cities.

5.1.2. Smart city. There are many terms used nowadays to describe a modern and sustainable city—smart city, intelligent city, green or innovation city. They are all extremely vague and allow a lot of room for individual interpretation and preferences [27].

Usually, a smart city (smart in the narrow sense) is considered to be sustainable, efficient and livable at the same time [27].

Vanolo [47] defines smart city as an efficient, technologically advanced, green and socially inclusive city. He focuses on six distinct characteristic of a smart city: (1) *smart economy*, i.e. innovation, entrepreneurship, flexibility of the labor market, integration in the international market and the ability to transform; (2) *smart mobility*, i.e. local and supra-local accessibility, availability of ICTs, modern, sustainable and safe transport system; (3) *smart governance*, i.e. participation in decision-making process, transparence of governance systems, availability of public services and quality of political strategies; (4) *smart environment*, i.e. attractiveness of natural conditions, lack of pollution and sustainable management of resources; (5) *smart living*, i.e. quality of life, availability of cultural and educational services, tourists attractions, social cohesion, healthy environment, personal safety and housing, and (6) *smart people*, i.e. level of qualification of human and social capital, flexibility, creativity, tolerance, cosmopolitanism and participation in public life.

However, there are many views on the definition of a smart city. Another (similar) concept is based upon four core areas of an smart city: (1) *intelligent energy concepts*, i.e. renewable energies, energy efficiency, energy saving measures; (2) *intelligent mobility*, i.e. innovative, infrastructural and logistical transport and traffic concepts; (3) *intelligent planning and governance*, i.e. smart city administration and structural measures in the redevelopment of real estate, streets or entire sections of a city, safety, and (4) *intelligent economy*, i.e. production, waste management, consumption patters, lifestyle [27].

Most of the world's population lives in urban areas. Current cities are very complex systems with different modes of transport, communication networks, services and utilities [35]. However, the rapid growth of the cities often generates traffic congestion and pollution [35;48]. Cities generate approx. 70% of the worldwide CO_2 emissions and cause air, water and environmental pollution [27]. Also, since a large part of global population lives in the urban area, the exposure of the cities to specific (climate change related) risks is very relevant, like e.g. frequent severe weather extremes that cause damage to buildings or infrastructure, or has negative effects on people's health [27]. Furthermore, cities generate the largest part of waste. Hence, intelligent disposal together with a sustainable recycling system in congested urban areas is essential [27].

Considering this development, the green economy (and governance towards it) has been one of the main themes in the international debates on sustainable development [36]. Urban green space provides critical ecosystem services and promotes physical activity, psychological well-being, and the general public health of urban residents. It improves life for city dwellers and may filter air, remove pollution, attenuate noise, and cool temperature [48].

With respect to these considerations as well as in view of the aforementioned divisions of a smart city, we defined two main categories and several indicators to measure smartness of our four investigated cities. The two main categories are the *smart mobility*, i.e. transportation means and use of these, and *smart environment*, i.e. green space, pollution, and sustainable resource management in the city. In terms of the *smart mobility*, we chose the following indicators: (1) no. of licensed cars in a city; (2) transportation availability, i.e. (2.1) length of the rail line as % of all streets in the city; (2.2) no. of train stations; (2.3) operating hours of the subway; (2.4) operating distance (bus and rail) in meters; (3) transportation use, i.e. (3.1) train use per year; (3.2) bus use per year; and (4) transport affordability, i.e. (4.1) cost of an one-day bus ticket; (4.2) cost of an one-day subway ticket; (4.3) annual private expenditure on communication and transportation in million Yen; (4.4) point 4.3 as % of the total annual private expenditure. The category *smart environment* includes following indicators: (1) attractiveness of natural conditions, i.e. (1.1) amount of parks; (1.2) total area of parks in square kilometers; (1.3) % share of parks in the total city area; (2) pollution, i.e. the carbon monoxide concentration (in ppm); (3) sustainable resource management, i.e. (3.1) use of water per 10,000 inhabitants in 1,000 m^3; (3.2) use of electricity (light) per 10,000 inhabitants in 1,000 kWh; and (3.3) use of electricity (power) per 10,000 inhabitants in 1,000 kWh.

In terms of smart infrastructure Tokyo is the unquestionable winner. The city offers the most train stations and the longest operating hours, it has the second (relatively) longest rail line (after Osaka), the use of the public transportation is the highest, and the (percentage) private expenditure on communication and transportation is second lowest (after Kyoto). Tokyo has also the biggest green space, together with Kyoto the lowest pollution level, and the most sustainable resource management regarding water and electricity (light). Yokohama is the second "smart" city and it rotates between second and third rank regarding the most indicators. Kyoto and Osaka performed similarly. Kyoto's problematic issues were the availability of transport and green space, whereas Osaka's were the transport affordability and sustainable resource management.

5.1.3. Knowledge city. Through recent economic changes, knowledge became an increasingly important factor. Nowadays, a greater value is created by economy from services than from industry or agriculture, and wealth is created more through utilization of human knowledge and creativity than through extraction and processing of natural resources [1]. In spite of these changes, a new theory of knowledge (based) economy emerged, which, according to Godin [21], is an umbrella concept, encompassing existing ideas and concepts on science and technology, and further indicators.

The knowledge economy, i.e. the production of knowledge, requires certain knowledge infrastructure and a vibrant urban life characterized by diversity and tolerance [16]. Knowledge economy as a learning economy requires the capability to learn and to expand knowledge, which can refer to a different subject, like e.g. science and technology systems (universities, research organizations, R&D) as well as economic structure, organizational forms and institutional set up [21].

Knowledge is one of the most important factors in today's economy, and therefore, there is a growing interest in the concept of the "knowledge city," which can provide the city with the (knowledge) infrastructure that nurtures the knowledge economy. The knowledge city has instruments to make knowledge accessible to citizens; it has a network of public libraries, cultural facilities and services with an educational strategy. Important institutions in a knowledge city are libraries, as „great libraries are not only about archiving the intellectual achievement of the past generation but can serve as a place for innovation" [12]. Universities also contribute innovativeness to a city and play an instrumental role in all visions and strategic plans of the knowledge cities. Also, most strategic plans of knowledge cities emphasize the role of knowledge intensive industrial districts and science parks [12].

According to Yigitcanlar and O'Connor [49], a knowledge city can be seen as an integrated city, which physically and institutionally combines the functions of a science park with civic and residential functions. A knowledge city concept includes following layers: (1) *knowledge base*, e.g. educational institutions and R&D-activities; (2) *industrial structure* that affects progress and initial development of a knowledge city; (3) *quality of life and urban amenities* in order to attract knowledge workers; (4) *urban diversity* and *cultural mix*, which encourage creativity; (5) *accessibility*, which encourages an facilitates transfer of knowledge; (6) *social equality and inclusion*, which minimizes social disparity, and (7) *scale of a city* (since larger cities tend to offer a greater knowledge pool, greater diversity and choice for knowledge workers) [49].

Furthermore, the important development tools for a knowledge city are: technology and communication, creativity and culture, human capital, knowledge workers, urban development clusters and spatial relationships [49]. In our research, we covered the advancement of technology and communication in the investigated cities with the investigation of the ubiquitous infrastructure (5.1.1), and the creativity and culture in the following subchapter (5.1.4) about creative infrastructure. The indicators of a knowledge city we investigated are divided into four categories: *knowledge intensive institutions*, *users and usage of knowledge intensive institutions*, *affordability*, and *knowledge output*. The first category includes such institutions as universities, science parks or libraries. Also, we included the public libraries evaluation by Mainka et al. [32]. In terms of the *user and usage*, we considered the amount of students, graduates and teachers at the universities, as well as annually lent books at the libraries. The *affordability* category included the tuition and fees at the universities (however, these are the same for all cities), and the annual private expenditure on education. The *knowledge output* is measured by the number of publications (available at Web of Science), and number of patent applications (according to STN Derwent database).

In terms of the knowledge infrastructure Tokyo is, again, the best city. It offers the most knowledge intensive institutions. The most scientific publications and patent applications come from there, and the (percentage) private expenditure on education is the second lowest (after Osaka). The second best cities are Kyoto and Osaka. Kyoto performed very well in terms of the users and usage of knowledge intensive institutions, and the second most patent applications originate from there; as for Osaka, its public library was the best one in the evaluation, and the second most scientific publications come from there. Yokohama stayed behind regarding the most aspects.

5.1.4. Creative city. Not only do the knowledge and information drive the economic growth and development, but also the creativity. It contributes to the entrepreneurship, fosters innovation and enhances productivity. In spite of the growing interface between creativity, culture and economy, the concept of creative economy emerged [46]. Creativity became central to the cities—the dominant industries of the 19th and 20th centuries depended on materials and industry, science and technology, however, the industries of the 21st century will depend on the generation of knowledge through creativity and innovation [30]. According to Hospers [25], the knowledge economy and globalization led to the point, where cities have to compete for the favors of inhabitants, companies and visitors, more than in the past. The cities benefit from attracting and retaining knowledge-workers or companies looking for a place to settle or to visit. In this competition every small detail can be decisive, hence, the involved cities have to become "creative cities" [25].

The drivers of the creative economy are technology, demand and tourism. The ICT development led to increased production, distribution and consumption of creative content. Tourism is growing worldwide and it contributes to creative industries as well, e.g. through selling creative goods and cultural services into tourist market [46]. Rising wealth allows people to spend more time on non-material related acitivities. ICT enables easier and cheaper access to information, efficient transport and communication facillitate collaboration [42]. Florida [15] argues that the information or knowledge economy is powered not by information or knowledge, but by the human creativity. He defines creativity as the ability to create meaningful new forms. There are further definitions of creativity, e.g. (1) creativity as generation of imaginative new ideas including radical newsness, innovation or solutions to a problem; (2) creative problem solution (either new or recombined) has to have value; (3) novel ideas have to be valuable or imply positive evaluation. All in all, creativity involves the generation of new ideas or recombination of known elements into something new, providing valuable solution to a problem [40].

A general definition of creative economy describes it as including occupation and industries focusing on the production and distribution of cultural goods, services and intellectual property [11]. According to Brinkley and Holloway [3], creativity-based industries are located in information and communication sector (publishing, movies, TV and radio), advertising, and, entertainment activities.

We defined three categories enhancing city's level of creativeness: *creative infrastructure*, *use of the creative infrastructure*, and *affordability*. The creative infrastructure includes institutions like theaters, museums and concert halls, as well as the creative industry (e.g. the amount of broadcasting companies and the amount of employees working in this sector). The *use* of this infrastructure may be revealed e.g. by the average annual amount of visitors to the biggest museums in the city. The *affordability* is expressed e.g. by the average costs of museum tickets.

The most creative city is undoubtedly Tokyo, as it has the most creative institutions, the biggest creative industry, as well as the highest amount of museum visitors. However, the average costs of museum tickets are the highest in Tokyo (and cheapest in Yokohama and Osaka). In most aspects Osaka took the second place. Yokohama and Kyoto rotated between the third and last place.

5.2. Japanese governmental programs to enhance "smartness"

"In many growing informational cities, there have been or are political programs to build necessary infrastructures and to coordinate the way toward them" [43]. "Government is the best place to start with managing issues surrounding smart infrastructure and creating the right environment for investment in smarter technologies" [44]. Cities and local governments play a major role in moving the urban areas towards a greener economy [36]. Therefore, in this chapter we provide an overview of the most promising political programs of the cities' governments, which aim at building a strong smart infrastructure.

5.2.1. Tokyo as a Smart Energy City. The Bureau of Environment of the Tokyo Metropolitan Government introduced a Smart Energy Strategy, were it set a goal of a policy for the smart energy saving initiative that should be pursued in summer 2012 and beyond, as well as measures for the metropolitan government to take in order to transform the city into a Smart Energy City in the future. For this purpose three important aspects were emphasized: (1) smart energy saving that maximizes the use of energy saving technologies and know-how; (2) expansion of low carbon use, distributed energy resources, and (3) optimal control of urban energy supply and demand via smarty energy management.

The metropolitan government already took some steps toward the smart energy city, when the post Great East Japan Earthquake power crisis forced energy savings. Furthermore, facing the greenhouse gas emissions, the promotion of further energy savings is important. Also, Tokyo as a city endangered by natural disasters has to improve its resistance by diversifying the energy supply sources.

The core concept of the "Smart Energy Saving" is based upon three principles: (1) "implement continuable (easy to continue with little effort) energy saving measures without causing an excessive burden while elimination wasteful power usage", (2) "identify the peak demand and save power (peak-cut) as needed" and (3) "in normal times, avoid the implementation of measures that undermine economic activities, the benefits of lively urban life and the comfortable environments in offices and households." The government undertakes measures to ensure the initiative to be permanent. This will by possible through holding seminars on energy saving and power demand reduction, cooperation with companies to promote a shift to energy saving-oriented business styles (e.g. revision of energy usage at retail stores regarding lighting and air conditioning), or support of the installation of demand-monitoring equipment (also independent power generation facilities or storage batteries). Regarding the measures concerning private households 4,000 certified advisors were providing advice on power-saving measures (door-to-door visits or free advice at diverse events organized by managing organization under the advisory program).

Some excellent results can already be seen, e.g. reduced power consumption by 18% through revising lighting brightness thanks to the cooperation between building owners and tenants, or reduced power consumption by 33% by managing power demand through real-time visualization of power usage.

Tokyo Metropolitan Government's other initiative—the Tokyo Vision 2020 includes further attempts to create a smart and green city. Some of the steps are the creation of smart grid, i.e. system optimizing supply and demand balance of electricity services by building and area, or creation of new greenery (more precisely 1,000 ha of new greenery) as urban parks, waterside greenery etc., also, doubling the roadside trees.

5.2.1. Yokohama Smart City Project. The Yokohama Smart City Project (YSCP) is a part of the national initiative for Japan Smart City, due to which experiments on developing a model of a smart city are being conducted (jscp.nepc.or.jp). The operational experiments are taking place in the City of Yokohama as a whole, with the focus on three districts. There are many housing complexes, offices and commercial buildings as well as one large-scale factory involved. There are different energy management systems (EMS) in focus, which consider their respective environment in managing energy (i.e. for houses and residential complexes the HEMS, for factories or office buildings the FEMS/BEMS). The community energy management system (CEMS) includes these different systems as well as the electronic vehicle (EV) stations and charging centers. The aim is to create an infrastructure enabling to apply renewable energies and to compensate the instability of weather-sensitive photovoltaic generation, as well as to verify the social demand. The outcome shall be a low-carbon city and citizens' sustainable relation towards energy.

Furthermore, the City of Yokohama is pursuing the "FutureCity" project, which is aiming at the creation and promotion of solutions for various social issues (environment and demography-related). From December 2011 the City of Yokohama has been making efforts in five categories: (1) low carbon and energy conservation; (2) water and environment; (3) super-aging society; (4) creativity; (5) challenge. The FutureCity initiative aims for the sustainable and smart city, because of the environmental and energy saving aspects, as well as the smart living (or the creative city) by promoting the culture art. Another environment-related initiative is the "Yokohama Green Valley" (city.yokohama.lg.jp) promoting the reduction of greenhouse gas and economical vitalization by the use of industry developed from the aspect of "environment". Also, it aims for improving the environmental education through collaboration with citizens.

The fruits of Yokohama's efforts of becoming a green and/or smart city can be already seen. In June 2013 Yokohama won the "Global Green City Award" during the UN "High Level Dialogue in Implementing Rio+20 Decisions on Sustainable Cities and Urban Transport" in Berlin. Yokohama was awarded "for its outstanding efforts to create a sustainable, green and livable city together with its citizens" (yokohama-city.de).

5.2.1. Kyoto—Smart City Challenge. The IBM Corporate Citizenship launched the Smarter Cities Challenge to help cities (chosen around the world) to become "smarter" over a three-year period. The City of Kyoto took part in this challenge and was awarded a grant in 2013. It has been engaged in the strategy to become more "walkable," what can be achieved by improving the effectiveness of public transport (and foot traffic). Kyoto faces some problems with the transport and communication infrastructures, as it is decentralized and lacks an integrated real-time data enabling the authorities to manage it. Furthermore, the chronic traffic congestion and carbon emission are increasing, the transportation ecosystem is disconnected, and the pedestrian together with bicycles have to compete for the access. Therefore, undertaking some serious steps to improve the public transportation, diversify it, and decrease the use of private automobiles was inevitable.

The IBM team worked together with the Mayor of Kyoto, Daisaku Kadokawa, his team and various stakeholders. The team defined nine key recommendations, which can be categorized into three areas [23]: (I) explore and exploit information, (II) change individual behaviors and attitudes, and (III) transform the transportation business model. The first area (I) includes the three recommendations—(1) create the world's first Institute for Future Transportation, (2) manage traffic using real-time data, and (3) provide integrated information kiosks to encourage use of public transportation. The second area encourages use of social media by the city to enhance its current approach and facilitate a two-way dialog with citizens about requirements and feedback on investments. It includes the following recommendations: (4) introduce dedicated routes for buses and bicycles, (5) built "aesthetic corners" that provide comfort services, and (6) create an awareness campaign that inspires everyone to walk. The last area is concerned with making the overall infrastructure more efficient and more profitable for business owners, and it includes the last three recommendations: (7) integrate the parking ecosystem, (8) create a collaborative taxi service (Taxi ConneXion), and (9) develop a hub and spoke transportation infrastructure.

These IBM team recommendations complement the Kyoto City ten-year master plan—the Miyako Plan, which focuses on the years 2011 to 2020. The initiative "Kyoto: a walkable city" is one of its most important strategies. The Kyoto's vision of the future in 10 years according to the Miyako Plan includes such points as: (I) "Kyoto: environmental symbiosis and low-carbon city"; (II) "Kyoto: a city that cultivates industry that contributes to the environment and society", or (III) "Kyoto: a city of learning" (city.kyoto.lg.jp). Hence, there is a strong focus on the environment and (with the IBM-support) transportation of the city, as well as further aspects concerning city's informativeness.

5.2.1. Osaka's Basic Environment Plan. Osaka`s government also aims at realization of a sustainable metropolitan model – "The Environmentally Advanced City of Osaka." In 2011, this Basic Environment Plan of Osaka was based upon three core pillars: (1) creation of a low-carbon society (through promotion of global warming awareness, low-carbon urban environment and creating new mechanisms to reduce CO2 emissions), (2) formation of a recycling-oriented society (through promotion of measures for general waste, promotion of industrial management and of recycling), and (3) ensuring comfortable urban environment (through urban environment creation, promotion of measures against the Heat Island Effect, preservation and improvement of the urban environment). Also, there was an emphasis on participation of and cooperation between all entities. The more precise goals are: regarding (1)—a over 25% reduction in total gas emissions of the 1990 levels by the year 2020, and over 80%-reduction by the year 2050; regarding (3) reducing the annual waste the Osaka City disposes to less than 1 million tons annually (from 1,1 million tons of waste). To promote recycling and proper disposal of industrial waste, the city enforced regulations of waste-generating businesses and industrial waste processing firms, as well as provides guidance for them. Furthermore, it is taking such measures as controlling toxic waste (e.g. asbestos and PCB), and promoting a recycling-oriented society. The comfortable urban environment is supposed to be achieved, i.e. with the Anti-Heat Island Effect Plan ("Heat Island" means the effect, when the temperatures in the urban center are higher than in the suburbs). Regarding the air quality, the city is continuously monitoring air pollutants, and it has reached the environmental standards regarding nitrogen dioxide, sulfur dioxide and carbon monoxide. Also, it is encouraging the use of eco-cars (environment-friendly, low-emission, fuel-efficient cars) and promoting green delivery services using eco-friendly cars for goods-transportation.

6. Discussion

In order to evaluate the performance of the four cities and create a ranking, we quantified all investigated indicators. For each aspect we created an initial ranking and assigned points from 0 to 1, with the interval of 0.25 points (1 point for the best performance, 0.25 for the worst performance; in case a city did not perform at all, e.g. there were no concert halls, we assigned 0 points). We calculated the mean value for each category and city (Figure 2), as well as the mean value of all categories.

The initial conclusions for the investigated infrastructures in section 5.1 are reflected in the mean values of the categories in Figure 2. The city with the best ubiquitous infrastructure is Osaka (with avg. 0.893 points), followed by Tokyo (0.675), Yokohama (0.571), and Kyoto (0.357). In terms of the smart infrastructure, Tokyo was undoubtedly the winner

(0.806 points), followed by Yokohama (0.611), Kyoto (0.597), and Osaka (0.583). Regarding the knowledge infrastructure, Tokyo was also at the top (0.863), followed by Kyoto and Osaka (0.688 points each), and Yokohama (0.613). The creative infrastructure shows the biggest divergences. Here, again, Tokyo was the best city (0.955), followed by Osaka (0.614), Yokohama (0.534), and Kyoto (0.364). All in all, the four cities performed well, as each city was the best one in several aspects. Therefore, the mean values for all categories are over average (0.5), i.e. Tokyo scored in average 0.825 points, Osaka 0.695, Yokohama 0.582, and Kyoto 0.502.

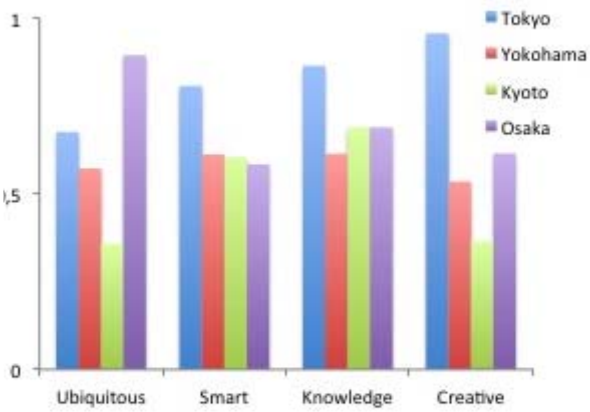

Figure 2. Mean values of all investigated categories.

7. Conclusion and Future Work

In this case study we formulated a framework of the informational and smart city, and investigated diverse infrastructures of four Japanese cities, based on it. We were able to rank the cities accordingly to their performance (however, only relatively to the performance of all investigated cities). In our future work we will define method to quantify the indicators independently from other cities' performance. We will also investigate further Japanese cities (like Kobe, Nagoya, or Sapporo), and include the results in the research on informational world cities.

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