Informational Cities: Analysis and Construction of Cities in the Knowledge Society

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Informational cities are prototypical cities of the knowledge society. If they are informational world cities, they are new centers of power. According to Manuel Castells (1989), in those cities space of flows (flows of money, power, and information) tend to override space of places. Information and communication technology infrastructures, cognitive infrastructures (as groundwork of knowledge cities and creative cities), and city-level knowledge management are of great importance. Digital libraries provide access to the global explicit knowledge. The informational city consists of creative clusters and spaces for personal contacts to stimulate sharing of implicit information. In such cities, we can observe job polarization in favor of well-trained employees. The corporate structure of informational cities is made up of financial services, knowledge-intensive high-tech industrial enterprises, companies of the information economy, and further creative and knowledge-intensive service enterprises. Weak location factors are facilities for culture, recreational activities, and consumption. Political willingness to create an informational city and e-governance activities are crucial aspects for the development of such cities. This conceptual article frames indicators which are able to mark the degree of "informativeness" of a city. Finally, based upon findings of network economy, we try to explain why certain cities master the transition to informational cities and others (lagging to relative insignificance) do not. The article connects findings of information science and of urbanistics and urban planning.

Cities From the Perspective of Information Science

City and regional research and information science: What do these areas of research have in common? Nothing, at first sight; neither were we able to find any literature concerning the intersection of both disciplines. With the advent of the knowledge society, however, a new type of city is arising: the "informational city" (Yigitcanlar, 2010). This is not merely a "knowledge city," with regard to mainly scientific knowledge and the institutions thereof (Carillo, 2006; Kunzmann, 2004; O'Mara, 2005), but also a "creative city" with regard to "copyright-based industries" or a "creative economy" (Evans, 2009; Florida, 2005; Landry, 2000). Since informational cities are not circumscribed by administrative borders but span entire regions, they also can be termed "informational metropolitan regions" (Castells, 2002, p. 550). The dominant infrastructures in informational cities are those that support "space of flows." This concerns both the infrastructure of information and communication technology (ICT) and the cognitive infrastructure—the provision of explicit knowledge, and in an "information-friendly milieu." The use of ICT, information dissemination, and knowledge management as well as theory and praxis of the information and knowledge society are genuinely information-scientific topics. We will apply these topics to cities: This is the novelty of this article. To our knowledge, this is the first attempt to investigate cities from an information-scientific perspective. Accordingly, we will start by carefully delimiting the terrain and hazarding some initial hypotheses. Just as many informational cities nowadays still are "embryos" (but likely to mature in the future), this article offers provisionally a heuristic to study such cities from an information science viewpoint.

For Tefko Saracevic (1995), information science has an "interdisciplinary nature" (p. 36). Information science is—following Saracevic—connected to information technology and to information sociology. ". . . (I)nformation science is, with many other fields, an active participant in the evolution of the information society. Information science has a strong social and human dimension, above and beyond technology" (Saracevic, 1999, p. 1052). This article has a very intensive interdisciplinary nature (most of the cited literature is not written by information scientists), it is on information technology (in cities) and it is—what is its main topic—on the development of the knowledge society and their social and human dimension (on the city level).

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In this conceptual effort, we will describe informational cities as typical cities of the knowledge society. The authority for the theoretical foundations of the investigation of such regions is Manuel Castells (1989), particularly his work "The Informational City." Since informational cities—at least insofar as they attain transregional significance—are "glocally" (globally as well as locally) oriented metropolises, we must deal with world cities and world city research. In the following paragraphs, we will turn to the infrastructures that are of central importance to informational cities: information and communication technologies infrastructure (ICT) and cognitive infrastructure. Here, we will learn that knowledge management not only can be meaningfully applied on the level of enterprises but also to the city as a whole. Informational cities have a particularly developed labor market, which is characterized by income and job polarization and tends to give high-paying jobs to highly qualified employees. Informational cities have a specific enterprise structure as well as sufficient leisure and enticing shopping facilities. In the building of informational cities, the political will to start such a project in the first place, and to finance its first steps, is essential. This article may be theoretical from start to finish, but it still aims to pave the way for an operationalization of its hypotheses. Accordingly, we first deal with the measurability of a city's state on the way to an informational city. Then, we attempt to find an explanation for successful developments of information cities. The theoretical foundation is network economics, with its prevalent Matthew Principle ("The rich get richer.") We conclude the article with a summary of the most important results.

This article is part of a larger research project on informational cities that is taking place in the Department of Information Science at the Heinrich-Heine-University Düsseldorf (Germany). Besides our theoretical considerations, there have been some empirical results on the nature of informational cities, such as measuring informational world cities (Nowag, Perez, & Stuckmann, 2011), job polarization in informational cities (Dornstädter, Finkelmeyer, & Shanmuganathan, 2011), and about Singapore as a "prototype" of an informational city (Khveshchanka, Mainka, & Peters, 2011).

The Ideal-Typical City of the Knowledge Society

Information Society—Knowledge Society—Network Society

"Information society" and "knowledge society" are topics that have been discussed for decades in information science, sociology, and economics (Godin, 2008b); "network society" is somewhat newer. Peter F. Drucker (1959) and Fritz Machlup (1962; also see Godin, 2008a) in the United States as well as Tadao Umesao (1963) and Yujiro Hayashi (1969) in Japan (Duff, Craig, & McNeill, 1996) were first to note the significance of knowledge and knowledge workers for society and economics. Roughly ten years after Machlup's "Knowledge Economy," Daniel Bell (1973) called this new society "postindustrial society" and, a further six years later, the "information society" (Bell, 1979; also see Duff, 1998). Alvin Toffler's "Third Wave" (1980) also described—after agriculture (first wave) and industry (second wave)—his third wave as a postindustrial society. A nine-volume work by Marc Uri Porat (1977) refined Machlup's approach and provided detailed statistical data of the information economy of the United States. However, diverse problems have hidden in that early deliberation of information society or knowledge society (Robinson, 1986; Schement, 1990). Delimiting information activities from all others is highly arbitrary. All people who do not obviously and exclusively work "with their hands" are information workers per definition. But a clear distinction between "thinking" and "doing by hands" is impossible (Webster, 1995). Paul Craven and Barry Wellman (1973) analyzed physical networks in the city (the "network city"); some years later, Wellman (2001) also described computer networks as social networks. For Manuel Castells (1996), the network society arose. In this sense, an information society and a knowledge society are a network-based society. But networks are very old forms of social organization. What is new is that "they have taken on a new life in the Information Age by becoming information networks, powered by new information technologies" (Castells, 2000, p. 15). In the sense of Leo A. Nefiodow (1991), the "basic innovation" of information technology will lead to another long wave (the fifth since the beginning of capitalism) of business cycles ("Kondratieff cycles," with respect to Kondratieff, 1926). The networks of the fifth Kondratieff wave are the networks of telecommunication, particularly the Internet. There are two main characteristics of this new form of society: the importance of digital information and the pronounced application of information networks (Linde & Stock, 2011).

What distinguishes the technology of the fifth Kondratieff? The resource information requires suitable information and communication-technological (i.e., telematic) devices and services: computers, networks, software, and so on. Additionally, enterprises, administrations, and citizens must be willing and able to adequately use these devices. From this follows a massive use of telematic devices, of information and communication technology, both professionally and privately.

Which regularities are proper to the resource information? The transmission of information, according to Manfred Bonitz (1986a, 1986b), rests on the basis of two simple, fundamental principles: the holographic principle and the speed principle. The holographic principle describes the space of information: "The entirety of human knowledge is one gigantic hologram, which consists of all storage units, databases etc. available to mankind" (Bonitz, 1986b, p. 192). The entirety of all information is thus virtually available everywhere. The speed principle addresses the movement of information in time: "According to it, every piece of information has the tendency to move so as to reach its recipient in the shortest amount of time possible" (Bonitz, 1986b, p. 192). The speed principle holds throughout the entire history of human communication, but from stage to

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stage, the movement has become increasingly faster. With every introduction of a new communication channel (e.g., books, magazines, reference databases, professional online databases, the Internet), a gain in time has been registered by society. With electronic information transmission in international networks such as the Internet, the speed limit has been reached. Information can be sent at the same time it is created and received in real time.

Knowledge changes—old wisdom loses its meaning, and new discoveries are made or developed further. For Martin Heidenreich (2002, p. 338), the significance of knowledge-based activity increases in a knowledge society, which leads to a change of status of education, and hence of learning. For every single member of a knowledge society, a lifetime of learning thus becomes essential.

We can now add up our working definitions for "information society" and "knowledge society." "Information society" refers to a society

- whose basic innovations are carried by the resource information and
- in which computers are of great importance.

A "knowledge society," on the other hand, is a society

- which displays all the characteristics of an information society,
  - at which *digital* information and
  - at which computer *networks* play important roles,
- in which information contents of every kind are available in any place and at any time (holographic and speed principles) and are intensively taken advantage of,
- in which lifelong learning (including learning how to learn) is necessary.

It is possible to represent the knowledge society as an "era" of human development. In this sense, the knowledge society replaces the industrial society, or the service society (Stehr, 1994).

In our definition, "knowledge society" and "network society" are synonymous. We chose "knowledge society" as the preferred term due to the great importance of knowledge for this form of society while networks are only the (admittedly necessary) carriers of knowledge. We have to add a terminological note: Not all authors of the cited literature use the terms "information society," "knowledge society," and "network society" in the same way as do we. The concept "informational city" is not established as well. We found in the literature many denotations, most of them referring to aspects of the informational city: "digital city" (Ishida, Ishiguro, & Nakanishi, 2002), "ubiquitous city" (Hwang, 2009), and "networked community" (Albert, 2008) refer to the communal ICT infrastructure, "knowledge city" (Carillo, 2006) refers to the application of scientific and technical knowledge during the development of the city, "creative city" (Florida, 2005) refers to the importance of the creative professions for the city, and finally, "cognitive city" (Tusnovics, 2007) refers to both knowledge and creativity in cities. We use "informational city" as a broader term for all these concepts. In addition, the concept "informational city" has a certain overlap with "world city" (Friedmann, 1995) and "global city" (Sassen, 2001). It is possible (most notable in quotations) that there is an inconsistent use of these terms.

Countries of the Knowledge Society

There are several established indicators, on the country level, which tell of the respective country's degree of development in general and more specifically with regard to the information and knowledge society. A complete overview on the societal development is granted by the "Human Development Index" (HDI; Anand & Sen, 1992), which is calculated by the development program of the United Nations (United Nations Development Programme, 2007). The HDI has a range of values from 0 (lowest) to 1 (highest) and takes into consideration four indicators:

- Life expectancy of population at the time of birth,
- Rate of alphabetization of adults,
- Ratio of pupils and students in their respective age groups,
- Gross Domestic Product per capita (in purchasing power parity dollars).

Composite indicators such as the HDI face the methodical problem of not having any precisely demarcated real object to be registered. Nevertheless, the HDI has asserted itself, at least as a vague parameter, for the registration of countries' state of development. The highest developed countries for 2005 are, according to the HDI, Iceland and Norway (with a value of 0.968), followed by Australia, Canada, and Ireland.

The "ICT Development Index" (IDI) of the International Telecommunications Union (ITU) reports on the influence of information and communication technologies on the development of a country. It consists of three partial indicators:

- ICT infrastructure and access: landline telephony, mobile telephony, Internet bandwidth per Internet user, ratio of households with computer and with Internet access.
- ICT usage: Internet users per residents, broadband users via landline and mobile accesses.
- ICT abilities: rate of alphabetization for adults, ratio of pupils and students in their respective age group (however, unlike in the HDI, only secondary and tertiary education is taken into consideration).

The countries with the highest ICT development are—according to the IDI for 2007—Sweden, ahead of South Korea, Denmark, The Netherlands, Iceland, Norway, and Luxembourg (all countries with an IDI >7) (International Telecommunication Union, 2009, p. 22).

HDI and IDI have a few aspects in common (alphabetization and ratio of students), but the very high correlation, of $R = +0.90$ (Pearson), of both value series still surprises: The higher the state of development of a country (according to the HDI), the higher the state of development of its information and communication technology will be, and vice versa (Figure 1).

A further indicator for the information society is the "Networked Readiness Index" (NRI) of the World Economic

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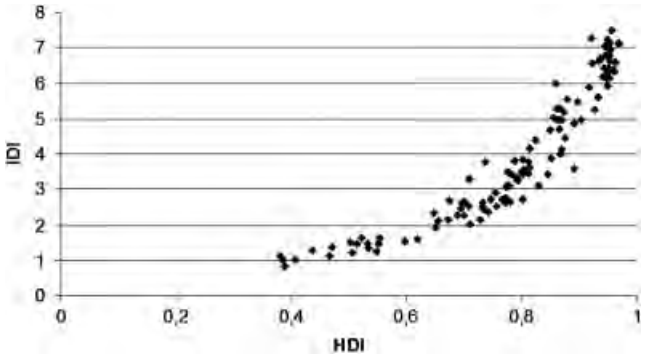

FIG. 1. Correlation between the Human Development Index (HDI) and the ICT Development Index (IDI) for 112 countries. Raw data: HDI, United Nations Development Programme (2007) (Year under review: 2005); IDI, International Telecommunication Union (2009) (Year under review: 2007).

Forum (Dutta & Mia, 2009). It consists of three partial indicators—environment, readiness, and usage—which are each in turn made up of three so-called *pillars*. For readiness and usage, distinctions are always being made according to, respectively, willingness to use and factual usage by single members of society, companies, and the government (in terms of eGovernment). The frontrunners (for 2007) according to the NRI are Denmark, Sweden, the United States, Singapore, Switzerland, Finland, and Iceland.

The correlation (Pearson) between the HDI and the NRI for 2005 amounts, for all the countries for which both values are available, to +0.75. As in the HDI–IDI comparison, this is a very high value, which suggests the following: The more developed a country is (operationalized following the HDI), the higher the state of development of its information society will tend to be (operationalized following the NRI), and vice versa (Peña-López, 2006). For the record, human development in general and development of the information and the knowledge societies go hand by hand.

Cities of the Knowledge Society

Part of the "geography of the fifth Kondratieff" (Hall, 1985) are cities. Just as there are typical cities of the industrial society (e.g., Manchester in the 19th and early 20th century) and the service society (e.g., Manhattan of the late 20th century), so there exist or will exist in the near future typical cities of the knowledge society. Following Castells (1989), we will call such cities "informational cities." In the literature of the 1980s, we also can find the term *information cities* (Hepworth, 1987, 1989) (The term "knowledge city," however it suggests itself, cannot be used, as it is already allotted in the literature, expressing a partial aspect of informational cities.) Such cities are not only "prototypes" of a city in the knowledge society but they also should be power centers of this form of society. Information processing and dissemination is an age-old function of cities (Mumford, 1961). So, what is special to cities of the knowledge society? What is an informational city?

Space of Flows—Castells' Image of Informational Cities

Castells as Urban Researcher

In knowledge societies, 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. The authority behind the theory of informational cities is Manuel Castells. In the 1970s and 1980s, Castells turned to researching cities—as yet without any regard to information and digital networks. Significant works from this period are *The Urban Question* (French 1972, English 1977), the collection of essays *City, Class and Power* (1978) and *The City and the Grassroots* (1983; also see Ward & McCann, 2006). Toward the end of the 1980s, the informational city enters his purview; the high point is his book *The Informational City* (1989) (Susser, 2002; Stalder, 2006, p. 162). After that, Castells cleaves to information and its networks as the focus of his research while broadening his perspective. For Simon Bromley (1999), *The Informational City* is a transitional work, "marking Castells's move from urban geographer to theorist of global society" (p. 17). The three-volume works *The Information Age* (1996–1998) as well as his monograph *The Internet Galaxy* (2001) contain comprehensive descriptions and analyses of the knowledge society, now called "network society" as well. When Castells published *The Informational City* in 1989, he could not have known how existing informational cities would look like (since the Internet had not yet happened), but the theoretical foundation for dealing scientifically with informational cities had been laid. Today, we have informational cities in front of our eyes: Singapore, Seoul, and Dubai set themselves the explicit goal of creating such cities (and are very far along the way); London, New York, San Francisco (and environs), Shanghai, and Hong Kong predominantly bank on high-tech industry and services and are modifying their regions into informational cities. Today—at the beginning of the 21st century—we can fill Castells' theory with life.

Markers of Informational Cities According to Castells

The starting point of Castells' deliberation is the informational revolution—a transitional phase of similarly enormous scope as was the industrial revolution. According to Castells (1989),

> A technological revolution of historic proportions is transforming the fundamental dimensions of human life: time and space. New scientific discoveries and industrial innovations are extending the productive capacity of working hours while superseding spatial distance in all realms of social activity. The unfolding promise of information technology opens up unlimited horizons of creativity and communication, inviting us to the exploration of new domains of experience, from our inner selves to the outer universe, challenging our societies to engage in a process of structural change. (p. 1).

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The informational revolution goes hand in hand with globalization—both have been happening nearly simultaneously in the latter years of the 20th century (Lippman Abu-Lughod, 1991, p. 408). Castells (1989) described his book's motivation in the following way:

> This book aims at analyzing the relationship between new information technologies and the urban and regional processes in the broader content of historical transformation in which these technologies emerge and evolve. Our hypothesis is that this context is characterized simultaneously by the emergence of a new mode of socio-technical organization (which we call the *informational mode of development*) and by restructuring of capitalism, as the fundamental matrix of institutional and economic organization in our society. (p. 2)

The informational revolution, with its alignment toward streams of information, capital, and power ("space of flows") fundamentally changes the character of the city with its previous alignment to acreage ("space of places"). Castells (1993/2006) defined the informational city:

> The new spatial logic, characteristic of the Informational City, is determined by the preeminence of the space of flows over the space of places. By space of flow I refer to the system of exchanges of information, capital, and power that structures the basic processes of societies, economies and states between different localities, regardless of localization. (p. 136)

Enterprises in informational cities interlink, among each other but also with the rest of the world, via digital networks. According to Castells (2001), such "glocal hubs" are specific areas throughout the entire planet, which link up with equivalent areas in any given location. So "the network society is a global society because networks have no boundaries" (Castells, 2010, p. 2737). Informational cities act "glocal"—global and local—as well. Glocality connects, in both word and deed, globality with locality (Wellman, 2002). Glocal cities can be found both in former industrial countries (e.g., the city of London, with offshoots in the West End and the Docklands) and in service societies (e.g., New York City) as well as in (former) threshold countries (e.g., Singapore or Dubai). From the point of view of infrastructure, such cities have two faces: On one hand, they have an infrastructure for geographical space (e.g., traffic, energy, or water); on the other hand, they have an infrastructure for digital space (e.g., telecommunication).

Technological centers of the space of flows do not randomly pop up in space but are characterized by two fundamental features:

- Dense spatial concentration (often at the periphery of agglomerations) (local aspect), and
- Digital connections with other centers (global aspect).

Examples for such centers are Silicon Valley on the edge of San Francisco (with, among others, eBay, Yahoo!, and Google) and the environs of Seattle (e.g., Microsoft and Amazon). For Castells (1996), the spatial and digital linking of companies of the knowledge society follows the theory of "small worlds" (Milgram, 1967; Watts & Strogatz, 1998). There are closely linked companies, both locally and globally, as well as short paths (either literally via spatial proximity, or via digital connections) to other players inside the city and to players anywhere in the world.

Informational cities also embody, as "dual cities" (Catterall, 2000), the meeting of information and noninformation professions, as Castells (1989) described:

> The new dual city can also be seen as the urban expression of the process of increasing differentiation of labor in two equally dynamic sectors within the growing economy: the information-based formal economy, and the down-graded labor-based informal economy. . . . Two equally dynamic sectors, interconnected by a number of symbiotic relationships, define specific labor markets and labor processes in such a way that the majority of workers are unlikely to move upwardly between them. The economy, and thus society, becomes functionally articulated but organizationally and socially segmented. (pp. 225–226)

It is thus very important to take a closer look at the labor market of such dual cities. We will come back to this problem. First, though, we want to enlarge upon the aspect of glocality and the centers in the space of flows. Glocal hubs play a decisive role in the world economy. Particularly important glocal cities are often also "world cities."

World Cities

World City Research

World city research arises with the fundamental work "The World City Hypothesis" by John Friedmann (1986), which has a direct reference to Castells' city research (1972/1977). It concerns the placement of a city in the world economy. The term *city* is defined economically and has nothing to do with administrative borders. "(W)orld Cities are large, urbanized regions that are defined by dense patterns of interactions rather than by political-administrative boundaries" (Friedmann, 1995, p. 23). For New York City, for instance, it can be observed that central services have been shifted away from Manhattan and into the suburban regions of Connecticut and New Jersey (Hall, 1997a, p. 319). The entire economically connected region of New York and environs thus forms the world city New York. Sometimes there are no clearly dominant centers in world cities. The largest city in the San Francisco Bay Area is not San Francisco but San José. However, San Francisco remains the key location for advanced services while the main economic basis of the region—Silicon Valley—is neither in San Francisco nor San José but between them (Castells, 2010, p. 2739). For Europe, too, such "mega city" regions can be detected (Hall & Pain, 2006), such as the Dutch Randstad (the region including the cities, more or less arranged in a circle, of Amsterdam, The Hague, Rotterdam, and Utrecht).

Saskia Sassen chose the term *global city* for such significant metropolises. "World cities," she says, have always existed, and the status of a city in the globalized world would be better expressed via "global city" (Sassen, 2001, p. XIX).

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In this article, however, we will use "world city" and "global city" synonymously.

World cities form a hierarchical system according to their respective significance (measured, for instance, by the capital that a city is able to attract and bind to itself). The number of residents by itself does not make a world city. Examples for cities with huge populations, but low significance in the world economy, are Mexico City, Jakarta, Dhaka, and Lagos. At the top of the world city pyramid are "the command and control centers of the global economy" (Friedmann, 1995, p. 23). They have a particular appeal for immigrants, due to their internationally noticeable status. Like Sassen (2001), Friedmann also regarded New York, London, and Tokyo as the leaders in this category for the last decade of the 20th century. On the second tier, we can see cities that may not dominate the entire world but still have a significance that goes beyond national borders. Examples stated include Miami, Los Angeles, Frankfurt, Randstad, and Singapore (Friedmann, 1995, p. 24). Friedmann allocated the third tier to cities with national significance (e.g., Paris, Seoul, and Sydney), and the fourth tier to regionally influential regions. On the fourth tier, as a "potential world city" (Friedmann, 1995, p. 44), there is the Rhein–Ruhr region (Düsseldorf–Köln–Essen–Dortmund). Options for operationalizing the measuring of a city's economic significance are the turnover of nearby stock exchanges (as an indicator for flows of capital) as well as the sums of profit of those companies that have their headquarters in the city in question (as an indicator of flows of power).

Friedmann (1995) incorporated Castells' thoughts on informational cities into world city research. As the result of this, we must define world cities via their placement in the space of flows.

> [Information-based] technologies, argues Castells, have created a deterritorialized "space of flow" which overcomes terrestrial barriers by creating instantaneous access to a network of strategic stations located around the world. One may wish to illustrate this with reference to the communication links that manage global air traffic or the financial dealings of world capital markets. Access to this space, and control over its principal nodes, have become critical for the players in the game of capital accumulation. By the same token, those who lack access to this networked space are disempowered and, to varying degrees, dependent on whatever crumbs of information power holders may be willing to share. (Friedmann, 1995, p. 28)

Following Sassen (2001), companies acting worldwide have their main headquarters in a global city. This attracts further companies as well as jobs, law firms, software providers, and so on which perform certain services for the corporations. All of these firms are dependent upon information—digitally available information as well as expert knowledge. The city becomes the information center.

> The mix of firms, talents, and expertise from a broad range of specialized fields makes a certain type of urban environment function as an information center. Being in a city becomes synonymous with being in an extremely intense and dense information loop. This is a type of information loop that as of now still cannot be replicated fully in electronic space, and has as one of its value-added features the fact of unforeseen and unplanned mixes of information, expertise and talent, which can produce a higher order of information. (Sassen, 2001, p. XX)

Global cities are production sites for companies in the information industry, and they are—since not all information can be expressed explicitly—places in which people meet to exchange knowledge. World or global cities are thus always "information-rich localities" (Flint & Taylor, 2007, p. 270).

Global cities have similar attributes, independent from their location and culture. All come with an amazing skyline of tower buildings, are financial centers, and provide many cultural events. But they include these global attributes in local traditions and give them "local color." Jonathan Matusitz (2010) called this "glurbanization:" "Urban spaces are restructured so that globalization does not become just a top-down hierarchical design whereby the nation-state dictates how things work; rather, globalization is made to happen both from 'below' and from 'above'" (p. 1). World cities—like other cities—are never in isolation but are always interlinked with other regions (Taylor, 2004). The relationships of these regions to their hinterland are called "townness;" the position of the region in the network of other regions on a global scale is called "cityness" (Taylor, Hoyler, & Verbruggen, 2010). For the analysis of the world city aspect, the cityness is particularly important.

How can we operationalize the position of a city in the international flow of information? What is an *informational* world city? Here, two indicators of informational connectivity can be applied: informational connectivity related to business and information connectivity related to science, technology, and medicine (STM). Informational business connectivity is created via different branches and offices of the same company (intrafirm networks) as well as locations of companies that are above and below it in the value chain, respectively (suppliers and clients; interfirm networks) (Lüthi, Thierstein, & Goebel, 2010; Rozenblat, 2010). To register the business information streams between cities, one can count all connections of companies from that city (whether they have headquarters or only a branch) to its respective branches as well as to steady suppliers and customers. Informational STM connectivity can be put into a simple indicator by using coauthorships (Melin & Persson, 1996). We look for all articles written by authors in the city (in a certain time window) and analyze in a second step the affiliation information of the coauthors on a city level. We can apply information services such as the *Web of Science* or *Scopus* (Nowag et al., 2011, worked with data from the Web of Science to calculate the informational STM connectivity of Singapore, London, and Düsseldorf.) It can be shown that coauthorship is no more than a partial indicator of STM collaboration because it is possible that coauthors never really worked together face-to-face (Katz & Martin, 1997). In a more sophisticated way, one can add citation data (White, Wellman, & Nazer, 2004). If we know (by affiliation data) which author works in which

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city, we are able to calculate "city co-citations" by aggregating the author–co-citation data (White & Griffith, 1981) to a city level.

The Unequal Geography of Success

Cities that have formerly been industrially oriented, and which have not mastered the transition to the informational city, as well as cities on the periphery of the world economy, including nearly all cities in developing countries, fall by the wayside (as "economic deadlands") (Brenner, 1998, p. 7). Small cities have only small chances for forming themselves into informational cities due to their lack of global links to other regions and limited labor markets. For Willem van Winden (2009), the "geography of success" is distributed very unequally in a knowledge society.

> Not every city is equally successful in developing new knowledge-based growth.... Some cities ... benefit from their particular innovative ability and enjoy healthy levels of economic growth.... Many other cities, however, lack such endowments and face the negative side of the emerging knowledge economy; they will lose economic activities and skilled people to other places and will have few opportunities to compensate for this loss. (p. 84)

If this phenomenon is not counteracted politically, a digital divide between prospering informational cities and all other regions will open up. (Winden, 2009, p. 87)

Infrastructure of Informational Cities

Infrastructure Changes in the Knowledge Society

For Peter J. Lor and Johannes L. Britz (2007), a knowledge society is based upon four pillars: (a) information and communication technology and connectivity (We will discuss it as "ICT infrastructure."), (b) content and the usability thereof (We will broaden this topic and speak of "cognitive infrastructure."), (c) infrastructure other than ICTs (We will shortly describe transportation infrastructure.) and (d) human capacity (which we will discuss as an aspect of cognitive infrastructure).

The fundamental networks of the past Kondratieff cycle were roads and motorways. As a prototype of a city in the fourth Kondratieff, we might think of turn-of-the-millennium Los Angeles, where highways and automobiles dominated the city. The fifth Kondratieff is being carried by ICT networks: Internet and intranet (Melzi, 2009). The transition from the fourth to the fifth Kondratieff is not always smooth. Particularly, countries with a strong automobile industry (and thus, inevitably, a strong auto lobby) are at a disadvantage. Here, industry and politics take great pains to artificially keep alive the infrastructure of the past long wave of the economy.

A great success was the demolition of a highway in Seoul, Korea, in favor of a little creek (the Cheong Gye Cheon; CGC) and a park. Such a freeway-to-greenway conversion is an expression of the infrastructure changes on the way to the knowledge society. Architects of the transition of the cities pay attention to "ecological wholeness" (Choi & Greenfield, 2009) or to "ecology" (Klaebe, Adkins, Foth, & Hearn, 2009). "The CGC project, perhaps more than any freeway removal to date, represents a recasting of public priorities. Specifically, it marks a shift from infrastructure that enhances 'automobility' to infrastructure that enhances public amenities and the quality of urban living" (Kang & Cervero, 2009, p. 2772).

Informational cities such as London and Singapore have reduced automobile traffic in their centers via inner city tolls. Hall also regarded this as a gain in quality of urban life. The implementation of this transition is a challenge to city planning.

> The key is to concentrate residences, work areas and amenities so as to produce the shortest possible trip distances, most being possible by bicycle and public transport. So housing sites are being sought first in the inner city, next on the urban periphery and only in the third place at more distant locations; wherever the sites are found, availability of public transport will be a key factor. (Hall, 1997b)

Examples for redesigned residential areas in close proximity to work are TriBeCa in Lower Manhattan and the entirely reshaped Docklands in London (Foster, 1999); however, this is always accompanied by gentrification (i.e., the displacement of lower income groups by richer residents).

Of course, there are still cars in informational cities—they just lose significance. Cars still play a role in connecting the city with its surroundings. Glocal cities support two kinds of traffic, however (Graham & Marvin, 2001): Locally, public transportation (particularly subway lines or other car-independent means of transport) is invested in—with a view to sustainability as well (Dur, Yigitcanlar, & Bunker, 2010); the rest of the world can be reached via airports (in an "airport metropolis;" Keast, Baker, & Brown, 2010), and additionally, perhaps, via high-speed trains that are directly connected to the airports (e.g., the Frankfurt Airport).

> [This] type of logistics enclave has perhaps the most dramatic contrasts between intense global connectivity and the increasingly careful filtering of local connectivity: the international "hub" airport or rail terminal. These are customised spaces par excellence for organising and housing global flows. In particular, such spaces are designed and regulated very carefully to meet the needs of affluent business and leisure travelers. (Graham, 2001, p. 6)

ICT Infrastructure

The predominant network of informational cities is its telecommunication network, which connects workplaces and private households with one another. The ICT infrastructure of a city is mainly based on telephony, broadband networks, and the Internet, forming the basis of the way these technologies are used in private households, in the economy, and in governmental institutions. The decisive factor is the number of technical devices or services in the city (i.e., the number of computers or mobile telephony contracts) as well as the penetration of these devices and services in the regional unit (displayed as relative values per resident or per household).

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Written and spoken text, images, videos, and audio files are transmitted via wires (copper or fiberglass) or wirelessly. Different devices (e.g., mobile phones, laptops, or PCs) are interlinked within *one* network (Yigitcanlar & Han, 2010). Additionally, there is—as planned in so-called *ubiquitous cities* (U-City)— free public access to the networks. Such U-City projects are being pursued in South Korea (e.g., in Seoul) in particular (Choi & Greenfield, 2009; Shin, 2009). For Jong-Sung Hwang (2009, p. 367), the U-City is even "the next paradigm of urban development."

Telephony is described via landline (indicator: main telephone connections per 100 residents), mobile network, and Voice over Internet Protocol. Broadband networking involves fast data networks such as the currently predominant Digital Subscriber Line (DSL), with data rates of up to 2 Mbit/s, or the upcoming very high speed DSL (VDSL), with data rates of 10 Mbit/s and more. The indicator bundle for the Internet registers Internet hosts, computer density (number and penetration of computers), Internet connection (households and companies with Internet access), and Internet users (people who have used the Internet within a certain time period, no matter where: at home, at work, in an Internet café). We can expect an informational city to provide (wireless) Internet access at any place in the municipal area, either for residents only or for everyone (e.g., U-Cities providing access via publicly accessible terminals, e.g., Seoul's "media pillars").

From a computer science view, there has emerged a new scientific branch called *urban informatics* (Foth, 2009). Topics of urban informatics are—in a nutshell—the ubiquity of digital technology, Internet services, and location-aware applications in cities. Related conceptions address "digital cities" (Loukis, Charalabidis, & Scholl, in press), which are "extensive information systems (including network infrastructures and applications running on them) that collect and organize the digital information of the corresponding 'physical city' and provide a public space for people living in and visiting them."

Cognitive Infrastructure

The cognitive infrastructure of an informational city cannot be described and measured via hard facts, like its ICT infrastructure, but rather concerns "soft" location factors—which are, however, of central importance for informational cities. According to Setunge and Kumar (2010), "urban infrastructure along the hard forms such as roads, electricity, water and sewers also includes the soft forms such as research, training, innovation and technology. Knowledge and creativity are keys to soft infrastructure and socioeconomic development" (p. 102).

Two types of cognitive activity are central for the informational city:

- Scientific–technical–medical activities and the results thereof ("knowledge city"),
- Creative–artistic activities and the results thereof ("creative city").

In the interplay of enterprises, municipal institutions, and academic facilities ("triple helix"), the required infrastructure will be developed (Etzkowitz & Klofsten, 2005). Since new knowledge is constantly being generated and distributed (as well as shared) via the exchange of information between the concerned parties, the cognitive infrastructure aims for constant learning—for the individual citizen, the institutions ("learning organizations:" Senge, 1990), and for the city as a whole ("learning city").

The Knowledge City

The knowledge society may be concerned with all sorts of knowledge, yet a particular significance is attained by STM knowledge (Böhme, 1997) since production is heavily driven by scientific–technical results (One need only think of biotechnical or environmentally sound products, which could hardly be produced without a scientific basis.) on one hand, and the population's opportunities in life are dependent on the level of science and technology on the other (directly—measured by life expectancy—on medicine and the health system, and indirectly—registered via status and income—by level of education, which is at least partially related to scientific and technical expertise). The use of ICT and knowledge economy supports economic sustainability (Nguyen, 2010). According to Ergazakis, Metaxiotis, and Psarras (2004), a knowledge society fosters such knowledge-driven developments and makes their results accessible to all citizens:

> A knowledge city is a city that aims at a knowledge-based development, by encouraging the continuous creation, sharing, evaluation, renewal and update of knowledge. This can be achieved through the continuous interaction between the citizens themselves and at the same time between them and other cities' citizens. This citizens' knowledge-sharing culture as well as the city's appropriate design, IT networks and infrastructures support these interactions. (p. 7)

In the knowledge city, the triple helix consists, apart from the municipal institutions for funding science, of public and private universities, further publicly funded research institutes (e.g., the Max Planck Institute in Germany), and the private research and development centers of economic enterprises (Kunzmann, 2004, p. 30). The development of a knowledge city can advance without any preestablished master plan (e.g., in Silicon Valley), but if the goal is to premeditatedly create such a region, according to Kunzmann (2009), strategic planning is required. In many cities, this is the task of the institutions for urban and spatial planning of each respective administrative unit ("knowledge-based development;" Knight, 1995, p. 225). "(K)nowledge-based urban development is a key planning approach for attracting and retaining knowledge workers and knowledge-intensive industries and also for the nurturing of knowledge cities" (Kunzmann, 2009, p. 47).

In the interplay between the different players in the knowledge city, transfer institutions play an important role. Enterprises seek contact to academic research and partially finance

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certain activities (e.g., establishment of professorships, allocation of research and development projects); universities shift formerly academic activities into the economy in the form of start-ups. There is a give-and-take of information between universities and enterprise: "(C)ompanies not only tap knowledge from the university, they also bring in knowledge that benefits the university" (Winden, 2009, p. 85). The informational city provides the appropriate spaces and allows, according to Matthiesen (2009), "KnowledgeScapes" to be created; that is, "different 'architectures of knowledge' ... and the distinct interaction dynamics within the fuzzy zones of translation, transaction and transcoding" (p. 11). Such zones of "trans" require corresponding professions, at the center of which is located the "trader of knowledge" (Matthiesen, 2009, p. 15), the information professional and the knowledge manager.

The placement of science parks is redefined in the informational city. Science parks in the knowledge society span the entire process from basic research via applied research up to product or process innovation, and not—as before—only the latter stages of the innovation process. It is necessary for the early phases of innovations in particular that universities be integrated into the science parks. "A first step in this direction would be to place future science park initiatives firmly within the institutional framework of existing higher education institutions" (Hansson, Husted, & Vestergaard, 2005, p. 1048). Cities (not only informational ones) are the homestead of knowledge. Feldman and Audretsch (1999) were able to demonstrate, for the United States, that around 96% of all innovations have happened in metropolises.

Evers (2008) called the meeting and ideal interplay between knowledge-intensive institutions in one region a "knowledge cluster:"

> Knowledge clusters are agglomerations of organizations that are production-oriented. Their production is primarily directed to knowledge as output or input. Knowledge clusters have the organizational capability to drive innovations and create new industries. They are central places within an epistemic landscape, i.e. in a wider structure of knowledge production and dissemination. (pp. 9–10)

Knowledge clusters (or their component parts) can be described as "knowledge hubs" (Evers, 2008, p. 10). These are hubs in local and global information flows that generate knowledge, transmit it (in the form of publications or patents), and train experts. The significance of a knowledge hub can be measured approximately both via the number of successful graduates and via the extent and effect of their STM publications. For the latter, some parameters such as number of citations in the *Science Citation Index*, in *Scopus*, or in the *World Patents Index* may be useful. Two indicators for this are known in scientometrics:

- Scientific–technical performance: number of publications (articles and patents granted),
- Scientific–technical impact: citations of these publications.

The most productive cities in the sense of scientific performance are (for 2004–2006) London, the Tokyo/Yokohama region, and the San Francisco Bay Area (Wichmann Matthiesen, Winkel Schwarz, & Find, 2010, p. 1884), and they are the top "world cities of knowledge." Here, I revisit general scientific databases and patent databases, respectively, since knowledge cities concentrate strongly on certain themes. Those themes (and as a consequence, certain institutions, academic and commercial, which specialize in them) quantitatively dominate the STM output of a region. Thus, for instance, the technical research of the German region Stuttgart (measured via patents granted) is characterized by developments in the area of combustion engines and automobile technology whereas in Munich (again in terms of patents), semiconductor devices are at the foreground (Altvater-Mackensen et al., 2005, pp. 513, 520). Such a thematic perspective will play an important role in determining the future potential of a knowledge city.

Examples for successful knowledge cities, according to Ergazakis, Ergazakis, Metaxiotis, and Charalabidis (2009), are Barcelona, Montreal, Munich, Dublin, Delft, and Singapore. We must add to this activities in Dubai (e.g., the *Dubai Knowledge Village* or the—tax-free—*Dubai Internet City*; Bagaeen, 2007).

Knowledge originates not only from science and technology but also from everyday life. Web 2.0 services especially disseminate such information. Do Web 2.0 services change the relationship between citizens and their city (Hardey, 2007)? There are images and videos of the city on Flickr and YouTube; Google with its Street View provides photos on buildings, streets, and neighborhoods of the city; people discuss and review companies and shops and their benefits and problems in weblogs, forums, and social shopping services; and finally, mashups (preferential Google Maps) bring all information together on a city map. For Hardey (2007), this leads to "a new 'synergistic relationship' linking individuals to data and localities they occupy or traverse" (p. 867). Social networks such as Facebook help to organize networks in the online world. But there are social networks in the real world as well. A challenge is to bridge online and real-world social networks on a city level (Kostakos & O'Neill, 2009).

The Creative City

Informational cities do not restrict themselves to only STM knowledge but also attract creatives and creative industries. Now, the creative city is by no means a new phenomenon; there have been and are bohemian neighborhoods in many cities (and not only in Paris). Richard L. Florida's (2005) thesis is that "creativity has become *the* principal driving force in the growth and development of cities, regions, and nations" (p. 1). Creative industries distinguish themselves via the individual creativity of its employees and their abilities and talents. Baum, O'Connor, and Yigitcanlar (2009, p. 48) named six industries that form the core of the creative city: (a) film, television, and entertainment; (b) authors, publishers, and print media; (c) composers and music production; (d) architecture, visual arts, and design; (e) advertising and marketing; and (f) the performing arts. Apart from the core

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professions of the creative class, there are points of contact with the typical professions of the knowledge city. "(T)he creative class also includes creative professionals who work in a wide range of knowledge-intensive industries" (Florida, 2005, p. 34).

In the creative city, certain quarters establish themselves in proximity to the city center, in which creative companies pool and—thanks to short distances—interlink; however, it also can be observed, via case histories from Australia, that such companies settle in the suburbs and interlink there (Collis, Felton, & Graham, 2010). We emphasize interlinking, which in this scenario has little to do with ICT and the transmission of explicit knowledge but is based instead on face-to-face contacts (Storper & Venables, 2004). As a "communicative metropolis," the city itself becomes a medium (Burd, 2008; Carpentier, 2008; Gumpert & Drucker, 2008).

"Old" creative cities are in global competition these days. Thus, the film industry in Hollywood is losing massive amounts of work to cities such as Vancouver or Toronto; *Lucasfilm Animations* (based in San Francisco), for example, opened a studio in the "global city for the arts," Singapore (Chang, 2000) in 2004 (Evans, 2009, p. 1026).

Knowledge Management on the City Level

Residents of an informational city collaborate in communicating and creating new knowledge, as David and Foray (2002) emphasized:

> Knowledge-based economies emerge when people, with the help of information and communication technologies, group together in an intense effort to co-produce (i.e., produce and exchange) new knowledge. This boils down to three main components: a significant number of a community's members combine to produce and reproduce new knowledge (diffuse sources of innovation); the community creates a "public" space for exchanging and circulating the knowledge; new information and communication technologies are intensively used to codify and transmit the new knowledge. (p. 14)

Knowledge has a particular characteristic: It cannot be transmitted as such. A sender can try to articulate knowledge and then let it be transported—as information—to a recipient via a channel. The recipient takes this information—insofar as he or she is able to interpret the signals meaningfully (i.e., sender and recipient must speak the same language)—and transforms it, on the basis of his or her own foreknowledge, into "his" or "her" knowledge. The knowledge meant by the sender and that interpreted by the recipient in the end does not have to be one and the same. "Information is knowledge in action" (Kuhlen, 1995, p. 34). But what is knowledge? What is being put in motion via information (Stock, 2007, pp. 19–28)? According to Popper (1972), we distinguish between subjective and objective knowledge, with the former being the knowledge of certain individuals and the latter—subject-independently—occurring in objective knowledge stores (books, databases, etc.). Knowledge has no form at first (in the sense that it exists independently of any carrier, "as such"); to be put in motion and transmitted between subjects, it must be given a form (hence, in*form*ation). This goes for every kind of knowledge. We would like to distinguish roughly between implicit and explicit knowledge. The latter is knowledge that can be fixed in documents and transmitted straightforwardly, in fixed form, via ICT. Implicit (or "tacit") knowledge is necessarily tied to the knowing individual. Polanyi's (1967) definition of implicit knowledge is this: "I shall consider human knowledge by starting from the fact that *we can know more than we can tell*" (p. 4, emphasis in the source). The transmission of such implicit knowledge occurs via imitation, socialization, or attempts at externalization, for example, via paraphrasing or metaphorical expressions (Nonaka & Takeuchi, 1995). Explicit knowledge can be digitally represented and organized via methods of knowledge representation (Stock & Stock, 2008), implicit knowledge is exclusively transmitted from person to person (Stock, Peters, & Weller, 2010). We must not overemphasize the role of the medium of information flows: face-to-face, telephone, e-mail, or via formal publications. Relations between the actors play the leading part and not the medium. "Although e-mail gets the lion's share of hype and analysis these days, it is relationship that is most important—and not the medium of communication" (Mok, Wellman, & Carrasco, 2010, p. 2778). The role of the city and of its citywide knowledge management is to maximize interactions. "Cities continue to foster face-to-face contacts and much contact is local. There is no global village. Rather, there is glocalisation, with extensive local contact joined by amplified long-distance connectivity" (Mok et al., 2010, p. 2781).

The usage and further development of explicit knowledge have two preconditions. On one hand, the knowledge will be present in the city in the form of documents (either digitally or physically); on the other hand, persons are needed who on the basis of their subjective preknowledge are able to do something with it (Ibert, 2007; Schamp, 2009). Put simply, "(K)nowledge is needed to use and to create more knowledge" (Evers, 2008, p. 18). In the case of implicit knowledge, we can see only one precondition: The "right" people must meet and cooperate. In this context, we should be aware of the strength of weak ties (Granovetter, 1973, 1983). Not only friends or colleagues (strong ties) but additional acquaintances (weak ties) interact with people. In small worlds (Milgram, 1967; Watts & Strogatz, 1998), some of our strong ties behave as "bridges" or "short cuts" to important other people. From a study by Haythornthwaite and Wellman (1998), we learn that the closeness of work ties and friendship ties is associated with more interaction between the persons (in this case, in a university research group), with greater frequency of communication, the exchange of more kinds of information, and the use of more media. Many of these ties operate in both cyberspace and physical space (Wellman, 2002).

Information flows occur within a company, between an enterprise, and all companies in its value chain, scientific institutions, and all other knowledge sources. The kind and extent of exchanged information here varies considerably. A supplier or client will likely be transmitted different

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TABLE 1. Information flows as the object of municipal knowledge management.

Information Flows	Within the company	Companies in the value chain	Universities	Other sources of knowledge
locally explicit	ICT (documents)	ICT (selected documents)	ICT (contract research)	ICT
locally implicit	personal, CoP	personal, CoP	personal, collaborative R&D	personal, creative clusters
globally explicit	ICT (documents)	ICT (selected documents)	ICT (contract research)	digital library
globally implicit	virtual teams	–	–	–

ICT = information and communication technology; CoP = Communities in Practice.

information than will be a competitor. We further distinguish between information flows on location; that is, within the informational city and in proximity of the companies' sites (local), and all other information streams (global). Table 1 lists in an overview the kinds of information flows. The task of knowledge management on the city level (Rashid, Metaxiotis, & Kausar, 2010) is to optimize the local explicit and implicit information flows.

For the companies of the informational city, this results in an interesting conflict. On one hand, it is necessary to develop one's own knowledge and keep it secret—at least for a certain time—to gain a knowledge advantage whereas on the other hand, one can profit from knowledge exchange within the city; that is, in Communities in Practice (CoP; Wenger, 1998), which are after all, defined by people's common interests and not necessarily their business affiliations. The proprietary, in-company knowledge is supposed to get to the company's branches, but not to other companies, neither in the informational city nor globally.

> Since, on the other hand, new knowledge within the company can only be created via communication with other organizations, the company, too, profits from the knowledge spillovers, unintended knowledge transfers via employees' private communication and intended knowledge transfers via labor piracy, imitation, knowledge acquisition (e.g. patents) or espionage discussed in the regional economy. (Schamp, 2009, p. 75)

For von Einem (2009), outside knowledge is particularly essential for companies and cities:

> One's place within the competition is thus not the result of one's own local research endeavors, but also fundamentally of the ability to . . . keep reinventing oneself, to learn in short periods of time, to quickly adopt new knowledge and to link it with one's own strengths. (p. 50)

Universities play two roles in municipal knowledge management: They are partners for contract research and joint research projects (Winden, 2009, p. 85), and they produce graduates, where the people finishing their studies ideally fit the local labor market. As soon as an informational city has achieved an initial "magnet effect" (von Einem, 2009), it will be able to satisfy the demands of its labor markets with outside manpower as well.

Knowledge management on the city level has two tasks. First, explicit world knowledge is to be made available (via libraries), and second, the informational city—above all, to strengthen implicit knowledge and interpersonal relationships—needs a knowledge-supporting local culture (Alfirevic, Pavicic, & Znidar, 2009).

Can knowledge management on the city level be imported? The simple answer is no. Following Stiglitz (2000), a knowledge infrastructure can only ever be built locally and never simply imported, as the local institutions will learn to successfully implement "their" knowledge in "their" country or city. Development aid for building an informational city can work only if the target learns to adequately use its own knowledge capacities, and is aware of the fact that a knowledge society, with its fundamental and always dynamic knowledge stores, is perpetually changing. Stiglitz emphasized:

> Thus if a global knowledge-based institution wants a country to learn a "truth" about development, then it should help the local knowledge institutes and policy makers to carry out the requisite research, experimentation and social dialogue to learn it themselves—to make it a "local social discovery." Creating this local knowledge infrastructure and practice entails "learning how to learn," that is, creating the capacity to close the knowledge gap, an essential part of a successful strategy. (p. 38)

The New Role of Libraries

In a knowledge city, instruments are provided that allow all citizens and companies access to the available knowledge in a systematic, efficient, and effective manner (Ergazakis et al., 2004). Successful knowledge cities always have, according to Ergazakis et al. (2009), a network of public libraries, with the residents having digital access to the library services via (cheap or even free) communication networks. The following holds for the knowledge cities under investigation (Barcelona, Montreal, etc.; discussed earlier):

> Regarding the [hypothesis] "Existence of network of public libraries is necessary" one basic conclusion is that the majority of cities cases currently offer the possibility to citizens to access a big bulk of the available libraries' material online. In this respect, it can be said that libraries are "digital." Thus, the hypothesis can be changed to "Existence of digital libraries network." (Ergazakis et al., 2009, p. 225)

The sociology of knowledge should not only concentrate research on the production of knowledge but also should analyze consumption of knowledge (Stehr, 2003). The "digital library" does not restrict itself to reference information (e.g., an online catalog) but includes all contents; that is, the full texts of all available media—without any cost for the library customers. After access to the digital networks has been

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granted via universal telecommunication services, the digital library offers an additional universal service for knowledge on the city level. We can distinguish between two models for realizing such a project (By the way: both will cost the city a lot.) In the Icelandic model, the entire population, independently of their place of access (i.e., including home PCs), is provided with the licensed literature. Thus, for example, every computer—in Reykjavik, for example—can be used to digitally search and read all specialist journals in Elsevier's *Science Direct* (van de Stadt & Thorsteinsdóttir, 2007). A second approach is pursued in Singapore; free access to the digital resources is provided to the residents of this city state (and to registered foreigners) either via their home PC (selected resources of general interest), via every library computer, or only via computers in selected libraries such as the National Library (Chellapandi, Han, & Boon, 2010; Sharma, Lim, & Boon, 2009). Here, only selected databases or digital magazines are made accessible to all citizens via their home PC while high-priced sources and highly specialized resources (e.g., the *Bloomberg Professional Service*) are available only in the libraries themselves. Compared to the Icelandic model, this approach requires less financing. The libraries' collaboration with the publishers is in sync with the known national licenses (Filipek, 2010), but on the city level ("city licenses"). Marketing is used to attempt to make sure that all citizens are aware of these information services and able to use them to their advantage (Dresel & Kaur, 2010; Heok & Luyt, 2010). The media in question include both fiction and particularly specialist literature, which is accumulated while tackling the problems of a knowledge city, or indeed a creative city.

Education

A condition that must be met for development of an informational city is that citizens will be able to meet the standards of the knowledge society. Lifelong learning is particularly essential. Additionally, the education system has the task of adequately training potential workers for the city's enterprises (Lim, 1999). Recruiting the workforce entirely from the native population will not be feasible; here, it is vital to globally allocate the demand for suitable manpower. The education system of an informational city roughly can be packaged into a quantitative parameter via the ratio of high-school and college graduates from any given age group.

Besides the physical access to knowledge, the system of education plays an important role in reference to the digital divide. This digital divide separates people who have access to networks and knowledge and are able to use it from people who have no access or who ignore networks and knowledge (van Dijk & Hacker, 2003). The digital divide—as information inequality—is an expression of social inequality in knowledge societies. Information-rich people profit by labor market and life in knowledge societies while the "information-poors" are more or less excluded from those benefits (Britz, 2004; Martin, 2005). It is possible to find this phenomenon concerning whole countries (Trkulja, 2010) and cities as well (Cartier, Castells, & Qiu, 2005; Hendry, 2000).

Labor Markets and Job Polarization

Income and Job Polarization

The current economic development has repercussions on income and jobs, which are characterized as income and job polarization, respectively (Autor & Katz, 1999; Kashefi, 1993). Income polarization means that the difference in income between the rich and the poor increases whereas the area between rich and poor loses significance. Boldly, one might express the hypothesis that "the middle class loses" (Goebel, Gornig, & Häußermann, 2010). Income polarization says nothing about any changes to specific professions. This is only accomplished by the conception of job polarization. Informatization is accompanied by the automatization of large economic areas. Routine tasks are increasingly being performed by (information) machines; the corresponding jobs (e.g., accounting or operating machinery) require fewer workers. For the workers, then, there remain the tasks that have not been automatized, and these are divided into manual (e.g., cleaning or building) and analytic (e.g., research and development) and interactive labor (e.g., management). The labor market in developed societies is split into well-paid (and well-trained) workers and (very) badly paid workers with limited qualifications—employees in the middle segment of education and income will, tendentially, disappear due to the increasing automatization of their former activities. Goos and Manning (2007, p. 118) characterized the remaining professions as "lousy and lovely jobs." Income and job polarization are, in the United States (Autor, Katz, & Kearney, 2006) and in Europe (Goos, Manning, & Salomons, 2009), regarded as empirically verified economic hypotheses. According to Goos et al. (2009),

> Since the early 1990s Europe, like the US and UK, has experienced job polarization, that is, a disproportionate increase in high-paid and low-paid employment. Pervasive job polarization is in line with the evidence that in advanced countries, technologies are becoming more intense in the use of non-routine tasks concentrated in high-paid and low-paid service jobs at the expense of routine tasks concentrated in manufacturing and clerical work. (p. 62)

The observable polarization can be explained via the increasing computerization of the working world. "We find that within industries, occupations, and education groups, computerization is associated with reduced labor input of routine manual and routine cognitive tasks and increased labor input of nonroutine cognitive tasks" (Autor, Levy, & Murname, 2003, p. 1279). While the use of ICT for routine tasks leads to job losses, it helps, in nonroutine tasks, to more efficiently perform such work. This is accompanied by demands upon employees to be able to adequately use ICT (Spitz-Oener, 2006).

Previous studies of the labor market in the knowledge society mainly have dealt with entire national economies. Here, we are interested in cities. Can income and job polarization

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also be found here? Can there be any particularities on the city level?

One of the few studies of polarization on the city level was conducted by Milkman and Dwyer (2002) on the example of the regions surrounding San Francisco and Los Angeles. The region surrounding San Francisco includes Silicon Valley; in the city, too, there were many Internet companies during the observed period of time. We thus can regard the Bay Area as an early form of an informational city, which cannot be said of Los Angeles during the same time. The labor market developments observed occurred between 1992 and 2000, during the emergence of the "New Economy." Incomes were divided into 10 groups; in each, 10% of all full-time workers can be found. Group 1 includes that one tenth of employees who earn the least, and Group 10 consists of the one tenth that earns the most. The result for Los Angeles more or less conforms to the expected results for job polarization (Figure 2). We see a U-shaped curve in the workplace development: pronounced on the edges (i.e., in the upper and lower income groups), less pronounced in the middle, with a net loss in the fifth decile. The situation is completely different in San Francisco: Here, we can observe a J-shaped curve with growth to be found exclusively in the upper income groups, particularly in the highest decile. Of the roughly 200,000 additional jobs in the 10th decile, around

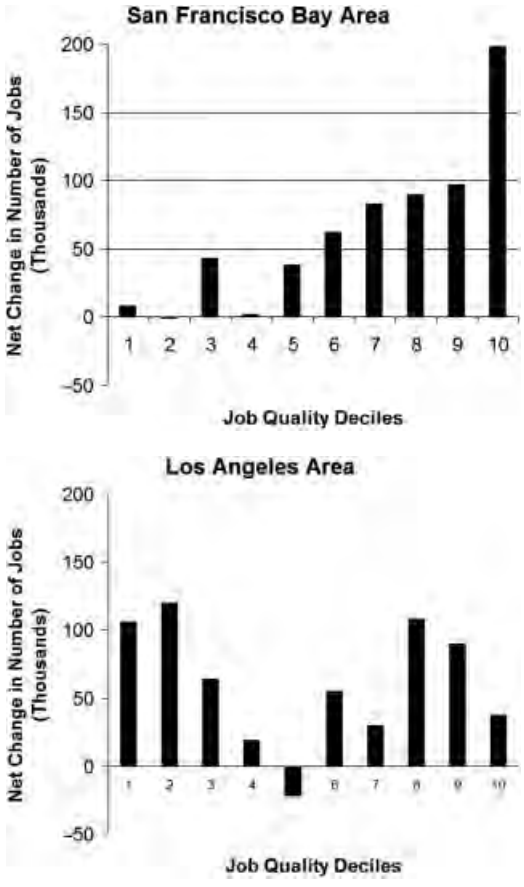

FIG. 2. Net workplace development (in thousands of jobs) by income deciles, full-time jobs, from 1992 through 2000 for the San Francisco Bay Area and the Los Angeles Area. Source: Milkman & Dwyer, 2002, p. 21.

160,000 are allotted to high-tech professions (Milkman & Dwyer, 2002, p. 25). The J-shaped curve progression appears only in the Bay Area in the 1990s; the decade before shows a typical U-shaped curve (Milkman & Dwyer, 2002, p. 25). The 1990s were the boom time for the information economy in the San Francisco Bay Area. Current empirical studies have demonstrated that there are clear positive correlations between the relative frequency of knowledge workers ("density of knowledge workers") and the innovative power of a region (Oort, Oud, & Raspe, 2009). Is this a first sign for a "highly unusual labor market" (Milkman & Dwyer, 2002, p. 24) in information cities? This would mean that not only does the middle class tend to stagnate in informational cities but so do the lower classes. Thus, the relation between the numbers of highly qualified workers to the rest changes in favor of the former.

Looking at the "lousy" jobs (i.e., at the left-hand side of the U-shaped curve), we can see that some cities do not rely on natives for such work (anymore). Observations of prospective informational cities such as Singapore (Dornstädter, Finkelmeyer, & Shanmuganathan, 2011) and Dubai point in this direction. Simple work (e.g., in construction) are not accomplished by native citizens but by foreign laborers, who may not bring their families with them or stay in the country after their work has been completed. The complete opposite applies at the other end of the work spectrum: Highly qualified foreign professionals (i.e., the right-hand side of the U- or J-shaped curve) are intensively courted—their (long-term) stay is desired. There are up-to-date results for the labor market in Singapore (Dornstädter et al., 2011): Neglecting the foreign workers, there is a J-shaped curve; including this temporary work force, we see a U-shaped graph.

Cultural Diversity and Municipal Labor Markets

The successful informational city will indeed have attracted manpower from the upper income classes due to its magnet effect (von Einem, 2009)—even from abroad. Here, two questions arise: How do these elites get along in a foreign culture? Is the cultural diversity thus brought about on the city's labor market useful? For all that the world is globalized, cultural and social patterns acquired in childhood and adolescence remain intact for a long time (Low, 1996). It is thus not surprising that cultural groups will meet in cities and build their own structures, starting from nationally aligned neighborhoods (e.g., Little Italy in New York City or Little Tokyo in Los Angeles) via "clubs" (i.e., the *Deutsches Haus* in Singapore) right up to specific schools for their children (e.g., the *German European School Singapore*). For Low (1996), such developments in the city play a compensatory role vis-à-vis globalization:

> Clearly, globalization of labor and capital has recast our urban landscape, but along with globalization comes a counter social force called "vernacularization." Vernacularization is the process by which the global is made local through the attribution of meaning. These local spatial/cultural communities provide the emotional and symbolic basis for maintaining cultural identity. (p. 60)

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Informational cities thus would be well advised to grant their foreign employees enough space for nurturing their cultural identity and to integrate these structures into the city (instead of relegating them, as "ghettos," to the margin) (Kunzmann, 2009).

There is a case study, for London, on the effects of cultural diversity on a municipal labor market (Lee & Nathan, 2010). The object of study was the influence of the ratio of foreign employees on the innovative activities of companies. The result is positive. "Overall, the results seem to bear out claims that London's diversity is an economic asset—at least in terms of its impact on innovation. If correct, this relationship implies that diversity has an important role in knowledge based development" (Lee & Nathan, 2010, p. 72). The collaboration of employees from different cultures thus seems to indeed be beneficial for the innovative environment of informational cities.

Social Consequences

What social consequences result from the structure of an informational city's labor market? The predominant economic form is still capitalism—here in the form of "information capitalism" (Bromley, 1999, p. 7; Fuchs, 2010). For Webster (1995, p. 210), the informational city has an interesting social component (and not necessarily a positive one) due to the informationally oriented companies' and institutions' employees. In the areas of the city in which either these companies are located or their employees live, the poor are excluded and the wealthy protected by security personnel. Webster named the example of London's Docklands. The former port facilities in East London were torn down and replaced by modern residential and office buildings.

> The Canary Wharf project, aiming to provide 71 acres and 50,000 jobs, was the most ambitious attempt to use the former docks for offices, expensive accommodation (close to the office, but unsuitable for children, hence ideal for yuppies), state-of-the-art rail links to the City, high-class restaurants, and an appealing ambience designed with the informational professionals uppermost in mind. . . . Those living and working in the area beforehand, the London working class, had been pushed aside. . . . Moreover, changes taking place increasingly *exclude the poor* by, for example, a marked expansion of housing and specialist estates which are gated and guarded to keep out the "dangerous classes." (Webster, 1995, pp. 209–210, emphasis in the source)

The rents in informational cities are at a very high level, not only in London's Docklands but also, for example, in San Francisco during the New Economy. The fact that an industry whose products are created and transmitted independently of time and place causes increased prices in real estate is somewhat ironic (Graham, 2002, p. 38). If an informational city wants to attract a foreign labor force, or students (who, after all, do not necessarily have the financial means to pay for "normal" apartments), this could be an obstacle for their immigration. On the other hand, many people are apparently prepared to accept alternative forms of living (e.g., Flat Sharing in London) only to be able to live and work (or study) in such a city.

In an informational city, the (former) working classes get in conflict with the informational elite (Susser, 1996), which they cannot win due to the one-sided polarization of jobs and are thus pushed into the suburbs or entirely out of the informational city. Income and job polarization are thus accompanied by a polarization of education. "With the creation of 'dual cities,' the extremes of poverty and wealth are concretized in the construction of urban neighborhoods with contrasting funds for education" (Susser, 1996, p. 43). The elites in the informational cities provide their children with a good education whereas the less educated and lower income classes (in the suburbs or other regions) tend not to. It could thus be a realistic scenario that next to the prosperous informational cities there will tend to exist poorer towns and regions, whose workforce will do the groundwork for the residents of the aforementioned cities.

> There are those highly trained to create the information processes and those less skilled who will operate and possibly maintain them. . . . Professional levels of education may be the even more rigid class divider. As we move through this new phase of capitalism, corporate-sponsored processes of communication networks and information flows are generating possibly ever more rigid inequalities. (Susser, 1996, pp. 43, 46)

There is a case study available concerning income polarization and its consequences for cities and their districts. Hulchanski (2007) advanced a long-term study of the developments in Toronto between 1970 and 2000. At the beginning, most of Toronto's districts and suburbs (66% of neighborhoods in all) are populated by members of the middle class (Hulchanski, 2007, p. 10). And in the Year 2000? "Middle-income neighbourhoods are now a minority and half of the city's neighborhoods are low-income" (Hulchanski, 2007, p. 5). In this case, this does not mean that the middle classes have emigrated into the suburbs, as there, too, the disappearance of the middle class can be observed. In 2000, only 32% of districts can be described as middle class; now, there are three different areas in Toronto. City 1 (with around 20% of residents) accounts for citizens with high income and high income growth over the observed 30 years (71% of income growth). City 2 represents the middle class. City 3 includes low-income districts and, compared over the period of observation, income losses (34% less income). In 1970, the socially problematic City 3 included around 19% of districts, and had spread to 50% in 2000. This results in ghettoization, or "poverty by postal code" (Hulchanski, 2007, p. 10); rich neighborhoods are confronted by poor ones.

Corporate Structure of Informational Cities

Specific Range of Businesses

Two areas are characteristic for the informational city (Gospodini, 2005, p. 1472):

- They are the seat of specific companies, which in their totality form a typically informational corporate structure.

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- They have comprehensive cultural institutions, a high offer of leisure activities, and enticing shopping facilities.

It is four types of companies in particular that have their headquarters here. First and foremost, capital-intensive service providers (as part of "advanced producer services," APS; Sassen, 2001) have their head offices in the global informational cities. The space of flows, in this case, is represented by the international stream of capital; participating branches are stock exchanges, banks, and insurance companies. In informational cities, too, there is industry, but those companies concentrate on knowledge-intensive, high-tech industries such as the medical, pharmacological, chemical, and agrarian industries. The third type includes, in a mixture of service providers and industrial companies, the information economy, to which belong industries such as computer manufacturing, software development, telecommunication, and Internet firms (e.g., search engine providers) as well as information service companies (producers and providers of information services). As a fourth pillar of companies, we list creative enterprises, which either assist (as further APS) the aforementioned companies (e.g., advertising agencies, architectural firms, or knowledge-intensive service providers such as consultants) or provide—in the context of soft location factors—cultural facilities (e.g., theater, opera, etc.).

All these companies have in common that to achieve their objectives, they absolutely require both an ICT and a cognitive infrastructure (knowledge city and creative city). Nowadays, one cannot build a stock exchange without a well-developed communication infrastructure, nor is it possible to successfully run knowledge-intensive industrial enterprises or service providers without access to (explicit) world knowledge.

All groups of enterprises and individual companies have—compared, for instance, to "old" industrial regions—a specific architectural aspiration and require an individual, specific interior design (Gospodini, 2006).

Disposing of Particular Sources of Income

The building and development of the information and cognitive infrastructure are expensive affairs, which must be supported with public money. Universal services, such as magazine and database subscriptions for all residents of the city, want to be financed. The successful informational city thus should have rich (tax) sources. This is already partly given with the capital and knowledge-intensive enterprises, but note that some informational cities have additional, always specific, sources of income. In Dubai, it is oil production, and in Singapore, its harbor (one of the world's largest).

Consumership and Leisure

Offers for "Cultural Omnivores," Architainment, and Attractive Riverbank Design

For Hall (1997a, p. 317), it is a mark of global cities to attract many foreign visitors (tourists as well as businessmen). Here, the following cultural institutions play a role: museums, galleries, libraries, opera houses, music halls, theaters, and the number of "events" in any given week. Casinos, too, will draw visitors. Furthermore, large sporting events with supraregional prominence are important (e.g., Formula One races or significant soccer or baseball games). A typical customer of an informational city's leisure facilities is the "cultural omnivore" (Peterson & Kern, 1996); that is, someone who cherishes "cultural mobility" (Emmison, 2003). In an informational city such as London, one can, at the same time, be a supporter of Arsenal Football Club, and a regular visitor to the British Library, go to the opera, or see a musical or a rock concert.

Some authors have regarded an imposing and well-lit city center, as well as its "skyline," as the figurehead of a city. One example to consider in this regard might be Las Vegas, whose structures have been defined as "architainment" (Klein, 2004, p. 330) or "electronic baroque" (Klein, 2004, p. 403), where the experience of the city is regarded as an event in itself. In many informational world cities, such a panorama comes about more or less automatically via the settlement of capital and knowledge-intensive companies' headquarters. Architainment involves both the identification of residents with "their" city as well as the magnet effect on foreign visitors. A current example is Dubai and its buildings—among them the Burj Khalifa, the tallest structure in the world.

> With ambitions to become a hub of global commerce, a top tourist destination and a shopping Mecca—a New York/Las Vegas/Miami rolled into one—Dubai has been spending billions of dollars to build an astonishing modern city nearly from the scratch in a mere 15 years. (Bagaeen, 2007, p. 173)

Many candidates for informational cities are located by the water—mostly the ocean and particularly the mouths of rivers as well as larger streams. During the industrial age, they housed many facilities of the manufacturing sector as well as harbors. With the transition to the informational city, though, these spaces have been fully redesigned architecturally and turned into attractive embankment areas. Gospodini (2001) emphasized this for Greek cities, but it also holds true for London (e.g., redesign of the south shore of the Thames), Manhattan (e.g., construction of park and sporting facilities on the Hudson River north of Battery Park), Dubai (e.g., on both shores of Dubai Creek), Singapore (e.g., particularly at the mouth of the Singapore River), and Düsseldorf (e.g., redesign of the Rheinhafen into a "media harbor").

The leisure and shopping facilities of glocal cities is reminiscent of an urban amusement park—one need only think of the Ferris wheels in the center of London or Singapore—causing Swyngedouw and Kaïka (2003) to speak of a "staged archaeological theme park" (p. 11).

Shopping Malls

One particularity of informational cities is their development into a "consumer landscape." Apart from the emphasis

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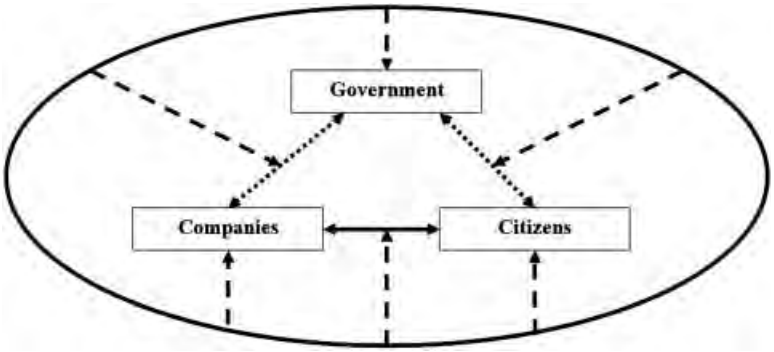

FIG. 3. e-Commerce, e-government, and e-governance. e-commerce: straight line; e-government: dotted line; e-governance: dashed line. Source: Gisler, 2001, p. 33.

on leisure and entertainment, the central aspect of consumption is, according to Webster (1995), shopping:

> At the heart of all this is consumption, and perhaps most notable, *shopping*, which in the postmodern city takes on a primary cultural role. . . . Here we are referring to shopping as *an end in itself*, as a pleasurable experience. . . . There is a slogan which captures this well (and in appropriate parodic form): "I shop therefore I am." (p. 212, emphasis in the source)

Both the number and the offer of shopping malls in advanced informational cities such as Singapore (Khveshchanka, Mainka, & Peters, 2011) and Dubai confirm this thesis. Note that we are speaking of physical "event" shopping, not about online purchases.

In professions with long working hours, leisure becomes scarce. Here, we can observe the tendency of shopping and other (leisure) activities coinciding both temporally and spatially. One does not only go shopping but meet friends and engages in common leisure activities: "The world in a shopping mall" (Crawford, 2004).

Political Programs and E-Governance

In many growing informational cities, there have been or are political programs to build necessary infrastructures and to coordinate the way toward them. "The overriding public policy need is for leadership in creating a cohesive framework for public and private investment in digital technology systems for communities" (Horan, 2001, p. 17). In Singapore, for example, we can observe manifold program activities, covering all areas of the infrastructure (e.g., *iN2015* for ICT, *Design Singapore* for the creative city, and *Library 2010* for the knowledge city); communal programs for the creative city are downright inflationary (the role model being *London Creative*).

Political intervention appears to be just as much of a necessity as it is support from the market powers (Zhao, 2010, p. 74). This is not e-government, and not the subsidization of e-commerce (Both come as a matter of course in an informational city, anyway.) but e-governance (Torres, Pina, & Acerete, 2006) (Figure 3). By this, we mean the instruments for directing construction of the informational city (Graham, 1997), be it via the creation of legal foundations, via systems of stimuli (e.g., tax reductions for enterprises in the information economy), via subsidizations of private initiatives, or via the city's own projects—primarily for ICT, traffic, and cognitive infrastructures as well as the (lifelong) education of its citizens. According to Gisler (2001), the development of the acceptance, as well as the encouragement of the usage, of ICT and their associated activities are accompanied by further tasks for e-governance. Yigitcanlar (2010) submitted a (certainly expandable) list of strategic activities for boosting the development of an informational city.

> The common strategies include political and societal will; strategic vision and development plans; financial support and strong investments; agencies to promote knowledge-based urban development; an international, multicultural character of the city; metropolitan Web portals; value creation for citizens; creation of urban innovative engines; assurance of knowledge society rights; low-cost access to advanced communication networks; research excellence; and robust public library networks. (p. 395)

Is an informational city possible without freedom of access of information (Lor & Britz, 2007)? We can observe, for example, for the informational city of Singapore (recognized as a "semi-authoritarian regime" by Kalathil & Boas, 2003, p. 10), that there does not exist entire freedom of the press (Kalathil & Boas, 2003, p. 70). Following Lor and Britz (2007), it is indeed possible to construct an information society with severe state control, but "a more multi-dimensional knowledge society cannot develop under such circumstances" (p. 387). Maybe there is a latent risk—in an informational city with severe control—for a shift from democracy to technocracy.

How to Measure the "Informationality" of a City?

If we want to model the significance of a city, parameters for trade or industrial production will no longer be enough to accurately portray glocal informational cities. Rather, we must work out their placement in the global space of flows. Here, too, we cannot stop at their administrative borders, as important companies may well shift their activities (or parts thereof) to the periphery of the city instead of remaining doggedly within the city limits. As the main indicator for the informational city, Hall (1997a) proposed access

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to information (both face-to-face and transmitted via ICT), accompanied by further values. The goal is to develop alternative procedures for measuring the attractiveness of different kinds of information activity in the city. "The outcome should be a new urban hierarchy of centres and sub-centres, based on position within a set of global information flows" (Hall, 1997a, p. 320). For Menou and Taylor (2006, p. 261) measuring information societies—and accordingly, informational cities—is a "grand challenge." Over the course of this article, we have addressed the following aspects, which may be suitable as indicators for informational cities:

- Infrastructure:
  - ICT
  - Knowledge City
    - Knowledge Clusters: Universities, science parks, etc.
    - Knowledge Hubs: College graduates, performance, and impact of STM publications and patents
  - Creative City (spaces for face-to-face information exchange)
  - Provision of Explicit Knowledge via Digital Libraries
  - Knowledge Management on the City Level
  - Education
  - Public Transportation
  - Airport
- Labor Market:
  - Workers in Knowledge-Intensive Professions
  - Workers in Creative Professions
  - Job and Income Polarization in Favor of Highly Paid Experts (There are first empirical results in Dornstädter et al., 2011)
- Corporate Structure:
  - Number and Significance of Capital-Intensive Service Providers
  - Number and Significance of Knowledge-Intensive Companies (high-tech industry)
  - Number and Significance of Companies in the Information Economy
  - Number and Significance of Creative Companies
- World City:
  - Number of Residents
  - Significance of Space of Flows (for initial empirical data, see Nowag et al., 2011):
    - Capital: Stock Exchange Turnover
    - Power: Sum of Profits of Companies With Headquarters in the City
    - Information: Informational Connectivity in Business and STM
  - Cultural Diversity and Individual Institutions for Foreigners
  - "Magnet Effect"
- Political Will:
  - Programs for Constructing an Informational City
  - E-Governance
- Soft Location Factors:
  - Number of Foreign Visitors
  - Leisure Facilities (culture, sports)
  - Architainment and Attractive River Banks
  - Shopping Malls

Suitable quantitative or qualitative parameters for each of these dimensions have yet to be tried out (for a case study of Singapore which applied most of these indicators, see Khveshchanka et al., 2011).

Development of the Informational City: Network Economics and Matthew Principle

An informational city is deeply ingrained in the knowledge society, which is based on digital information and information networks. On information markets (Linde & Stock, 2011), it can be observed that the development of standards follows principles of network economics (Shapiro & Varian, 1998, 2003). After a "combat zone," in which several candidates for the future standard meet and "do battle," one of the candidates reaches the critical mass of users and pretty much lifts off whereas his or her competitors lose market share and, in the best case, are still able to service niche markets. The successful candidate gains new customers purely on the strength of the market power he or she has acquired thus far, improves his or her offer, which attracts more customers, and so on. In cybernetics, this principle is characterized as a "positive feedback loop," it is said that "success breeds success," and in the gospel according to St. Matthew, we read: "Whosoever has, to him shall be given" (Matthew 13:12). The many iterations of the loop result in the establishment of one single standard ("The winner takes it all.") for one (technological, economic, regional) area; this does not have to be the best of all solutions—it is, rather, the solution that was able to convince the most customers. We see such standards in ICT (e.g., *Microsoft* for operating system and office software or HTTP for network protocols), but also in the case of certain information contents (*Google* for search engines, *Facebook* for social networks, or *Amazon* for online book stores). Partly, such standards are restricted to regions. *Google* may dominate the German and the American market, but not China or South Korea (There, *Baidu* and *Naver* are on top, respectively.) Does this principle of network economics also hold for the development of informational cities? If so, the result would be, from a global perspective, one single informational world city, or between one and a select few per world region.

Figure 4 shows a possible explanation. We start from the indicators worked out in the last paragraph. We regard a straight-line, monocausal connection as erroneous, and advance the hypothesis that all indicators are interlinked among one another. If, for instance, the positive will to construct an informational city is given, public investments will greatly improve the ICT and cognitive infrastructure, which will attract the desired kinds of enterprise, resulting in a changed labor market. The city becomes more attractive for professionals in knowledge-intensive and creative industries, working its way up in the hierarchy of world cities. The soft location factors, now matured, increase the city's magnet effect: Further companies and workers arrive and pay taxes, which in the continued presence of political will is used to optimize infrastructure, and so on.

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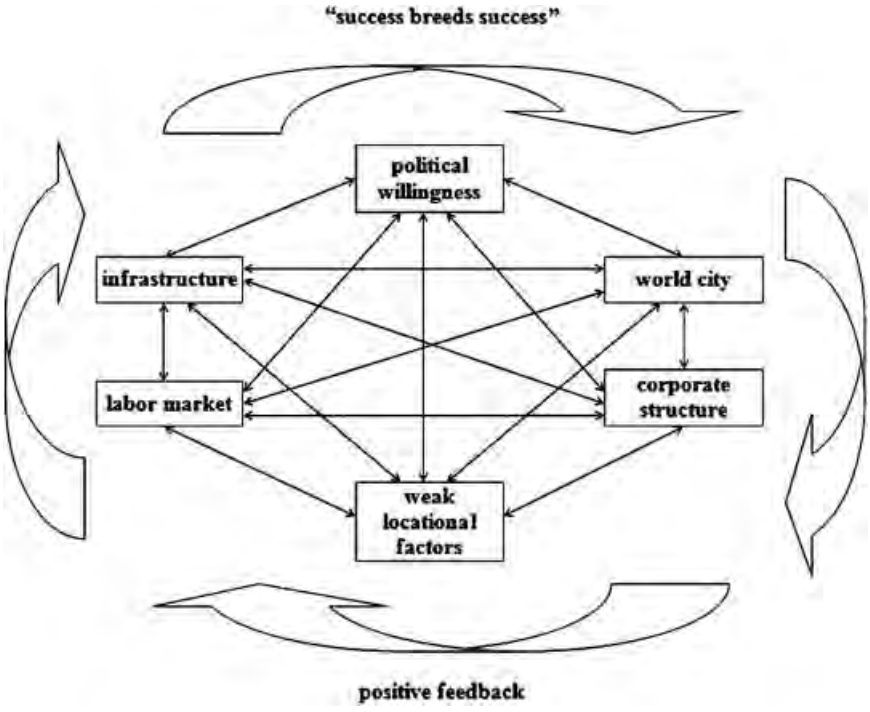

FIG. 4. The development of an informational city from the perspective of network economics.

It is of little importance where the point of entry into the structure of the informational city is located. In Singapore, it is the political will; in London, the corporate structure, developed over several decades, and its role as a metropolis have been more important. In San Francisco and the Bay Area, it is probably the labor market of scientists and creatives; in Dubai, it is a combination of political will, infrastructure, and soft location factors. Wherever the entry is made, once a positive feedback loop is reached, a city's chances of becoming an informational world city rise. There are few world cities at the moment; it is not difficult to pronounce that there likewise will be few informational world cities in the future. If the hypothesis of network economics is indeed true, all non-informational cities will have to face the fact that (according to Matthew 13:12) "Whosoever hath not, from him shall be taken away even that he hath;" that is, those cities will become relatively meaningless in the knowledge society. In view of the results of world city research, we can assume that informational cities, too, have a hierarchy. Very few informational cities (which are simultaneously world cities) dominate the entire global economy; apart from them, there are regional and perhaps national informational cities.

Some questions arise for cities that strive to become informational cities, and for the countries in which they are situated (M. Stock, personal communication, October 6, 2010):

- Can a country even afford not to invest in the construction of at least one informational city within its borders? Or is it enough that the country as a whole is an informational country?
- If a country invests in the construction and development of an informational city, will this be at the expense of its other cities? Does a successfully established informational city bring advantages or disadvantages to the other cities or regions? Does the informational city cause welfare effects for the entire country or will it bleed the other regions dry?
- In informational cities (at least on the upper hierarchy levels), capital and information are condensed into a new power within the state. Does this exclusively involve the companies' profit maximization? What about social questions in such a "knowledge-intensive capitalism?" How will the citizens profit? Are perfect shopping malls and architainment really satisfactory options?
- In informational cities, there is massive social inequality between well-paid elites and low-income, badly trained workers. What measures are being taken to counteract the impoverishment of wide circles of society and to prevent ghettoization? Under what conditions are informational cities places worth living in? Closing the digital divide in the sense of social justice is a big challenge—not only in informational cities but in knowledge societies in general (Britz, 2004, 2008; Duff, 2011).

Conclusion

Research into informational cities is situated in the intersection between the two disciplines of information science and city and regional research.

Our starting hypothesis was that informational cities are prototypical cities of the knowledge society. If the knowledge society does indeed represent a Kondratieff cycle, or even a historical epoch, it will be crucially important for cities to strive to resemble this type of city so as not to become insignificant.

In informational cities in the sense defined by Castells (1989), space of flows (power, capital, and information

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streams) dominates the traditional space of places. Informational cities are developed as a consequence of the informational revolution and changes in the capitalist system (in the sense of globalization). They are glocally aligned, acting on both the global and the local levels. With regard to the labor market, they are dual cities, in which the noninformational professions, which are growing evermore insignificant, are confronted by the crucially important informational professions.

According to Friedmann (1986), world cities—measured via their role in the global economy—are situated in a hierarchy which reaches from globally important cities, via cities that dominate world regions, to those with national or only regional importance. The global cities (on the first tier of the hierarchy) are the seat of important companies as well as their fundamental service providers. Global cities, today, are always informational cities (information centers following Sassen, 2001), which dispose of explicit (i.e., digitally available) knowledge as well as knowledge carriers (i.e., experts). Such cities are interconnected among each other. Important characteristics of informational world cities and their position in the hierarchy are (a) the amount of capital flows (stock exchange turnover), (b) the amount of power flows (as indicated by the sum of profits of their companies), and (c) the amount of information flows (the connectivity of the city with regard to business and STM).

The networks of the fourth Kondratieff (motorways, roads in city centers) lose their importance in informational cities; the networks of the fifth Kondratieff (i.e., networks of information and communication technology) are predominant. Additionally, informational cities have good traffic infrastructures with regard to short-distance traffic (subway lines) and air traffic. The ICT infrastructure of a city rests on telephony, broadband networking, and the Internet.

The cognitive infrastructure consists of institutions for supporting both the knowledge city and the creative city. The knowledge city involves both the creation and transmission of STM knowledge; the creative city provides spaces for networking activities, which take place mainly from face-to-face. Knowledge management on the city level works toward infrastructures for streams of explicit information and for the personal exchange of (explicit, but mainly implicit) knowledge. The libraries of informational cities take a central position as digital libraries, offering all residents (and companies) free access to necessary specialist literature and providing for the required information awareness via suitable marketing endeavors. The cognitive infrastructure of a city also involves its education system, which prepares an adequate workforce prepared for the requirements of the knowledge society.

In informational cities, there is income and job polarization to the benefit of (very) well-trained professionals. Of course, there are still jobs in the middle- and lower income spectra, but these lose in significance and are—as far as this can be realized via short-term labor—filled by foreign workers (under restrictive conditions). In view of high levels of rent, members of lower income classes are displaced from central locations of the informational cities (or even from the cities in general). Cultural diversity enriches the city's innovative power while the city reciprocally allows the foreign elites to nurture their cultural identities via pertinent institutions.

Four types of enterprises dominate the informational city: financial service providers, knowledge-intensive high-tech industry sectors, companies of the information economy, and further creative and knowledge-intensive service companies. All are absolutely reliant on ICT and cognitive infrastructures.

Institutions for culture, leisure, and consumption form soft location factors. The manifold cultural and leisure facilities address (among others) the "cultural omnivore;" the skyline and the lighting provide architainment; if there are river banks, these are attractively designed; and consumption takes place in shopping malls as event shopping.

Of essential importance for the construction of an informational city is the political will to reach such a goal. This involves regulatory activities (e-governance) and particularly original programs to build and develop all infrastructures of the knowledge society as well as to educate the citizens.

The old indicators for measuring the global significance of a city (i.e., numbers regarding industrial production) have become obsolete. What is decisive is the city's placement in the worldwide space of flows. We proposed six bundles of indicators, which allow for the measuring of a city's informationality: infrastructures, labor market, corporate structure, world city, political will, and soft location factors.

As a hypothesis for explaining the development of informational cities, we draw on network economics. According to the results of this theoretical structure, there will be very few informational cities worldwide, who are the "winners," and a huge number of losers. Cities thus will be recommended to show political initiative for building and developing their ICT and cognitive infrastructure as well as their citywide knowledge management. From the perspective of libraries, it must be added that cities are well advised to invest massively in the creation of a digital library (with free offers for all citizens).

Information science *and* city and regional research have proven to be successful strategies. The informational city has a hybrid character, being aligned both to physical spaces (space of places) and to information streams (as parts of the space of flows). This is expressed somewhat prosaically by Couclelis (2007): "We now live in two parallel worlds, one made of atoms, the other made of bits" (p. 72). The goal is to unite both of these "worlds," which Horan (2001) reduced into the concise formula: Informational cities are "hybrid places . . . that are both wired and livable" (p. 12). City and regional research deals with the analysis and design of the physical aspects of both spaces: information science with the information flows and underlying knowledge in these spaces. Both disciplines rely upon each other: City and space research lack essential knowledge about digital libraries, knowledge representation, information dissemination, and knowledge management; information science lacks the entirety of knowledge about physical spaces and design options.

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Outlook: Informational Cities and Information Science

Which aspects of informational city research concern information science? Inside the space of flows, information science is mainly interested in the flows of information. In world city research, information science, or—more precisely—*informetrics* and *scientometrics*, have to find appropriate indicators for a city's position in the international information flows. We suggested working with the number of connections between companies to capture information connectivity of business and with coauthorships and city co-citations to quantify informational connectivity in STM. Research on the cities' ICT infrastructure is primarily a task of urban informatics, but information science can contribute via *information architecture* to the construction of digital cities by analyzing and building up community Web pages, Web sites, and navigation systems for those sites. The knowledge city is based on STM knowledge. The organization, retrieval, and dissemination of such knowledge have been central topics of information science since its beginnings. *Knowledge organization* and *information retrieval* provide the supply of the right pieces of knowledge in every process of decision making. To quantify the importance of a knowledge city (or a knowledge hub), we apply standard methods of informetrics; namely, publication analysis and citation analysis. *Knowledge management*—in our case, on a city level—analyzes and organizes the dissemination and sharing of information inside the community and the import of explicit knowledge from the entire world into the city. In this context, *digital libraries* play a decisive role. Libraries acquire all needed information resources (e.g., databases and full texts of journals and books) and deliver them to the citizens and companies in the city. To estimate what is needed, information scientists conduct *user research*. Via *information marketing*, they make sure that the citizens and the companies know about the libraries' offerings. Because the operation of such all-encompassing digital libraries is very expensive, librarians discuss reasonable financing models. Knowledge management analyzes and supports the sharing of (explicit and implicit) knowledge between persons as well. Here, we do not stress flows of digital information but arrange interpersonal relationships. The companies and the government of the informational city are in need of the appropriate manpower. What is the future role of *information professionals* (information scientists as well as practitioners) to fulfill such tasks? In informational cities, we can find job polarization and other forms of social consequences of the emergence of the knowledge society (e.g., gentrification and the digital divide), which are aspects of a *sociology of information* and of *information ethics*. One of the main challenges of informational cities is the training of their people—as members of the workforce and as citizens as well. The educational system has to make sure that that all people have *information literacy*; that they are able to work and live with information technology, digital information, and Internet services. Should information science emerge to be an obligatory subject in schools of an informational city?

The next steps of informational city research are to perform empirical studies on selected cities to replace our somewhat speculative hypotheses by sound empirically justified propositions. We hope that this article is a starting signal for further research on cities in the knowledge society—also and especially from an information science view. In this way, information science will be present at the analysis and construction of informational cities in particular and of the knowledge society in general.

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