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ORIGINAL ARTICLE

A comparison of smart city research and practice in Sweden and Japan: trends and opportunities identified from a literature review and co-occurrence network analysis

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Abstract
Smart cities continue to be conceived and implemented around the world as literature documenting these trends grows at a similar pace. Practices focused on narrow techno-economic objectives have met with sharp criticism as scholars have called for human-centred smart cities that explicitly address social issues and the needs of residents. Yet, literature has made few attempts to systematically compare a representative sample of smart city practices and discussions using objective methods that combine quantitative and qualitative approaches. This study thus focuses on Sweden and Japan as two nations particularly active in the implementation and discussion of smart cities. To compare the state of discussions and practices in each country, we examine a sample of almost 2,000 academic studies published since 2010. Using co-occurrence network analysis (a type of content analysis), we objectively identify the thematic foci of discourse and practices in each country. We then explore the themes characterising each country's network with qualitative descriptions from the sampled literature. Our analysis reveals unique trends in both countries related to the conceptual framing of smart cities, participation of local government and citizens, and differing interpretations of vulnerability to hazards. Overall, combined findings from both countries reveal that technology-focused discussions are dominating over social topics, such as human capital, stakeholder participation, governance, social equity and so forth. The absence of socially oriented research is more pronounced, however, in Japan. These findings provide important cues for future smart city research, policy and practice.

Keywords Smart city · Sustainable city · Content analysis · Japan · Sweden · International comparison

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Introduction

The smart city paradigm is increasingly integrated into urban development around the world as a core strategy to promote environmental sustainability, economic growth and social prosperity. Smart city projects often appear with varying and overlapping labels, including "smart", "sustainable" (Höjer and Wangel 2014), "digital" (Nam and Pardo 2011), "intelligent" (Albino et al. 2015) and "automated" or "autonomous" (Cugurullo 2020), etc. In terms of basic components, there is wide consensus that the essence of the smart city lies in the integration of digital artefacts and processes into urban infrastructure and planning through information and communication technologies (ICTs), sensors, data analytics and automation (Caragliu et al. 2011; Dameri and Benevolo 2016; Meijer et al. 2016). However, there are considerable opportunities for variation amongst individual smart cities and countries (Min Kim et al. 2021). These can emerge from differing conceptualisations of smart innovation (Joss

2019) as well as the precise societal objectives that guide the selection of particular technologies and their integration into environmental and human systems (Trencher 2019).

The differing possibilities, manifestations and problems of smart cities proliferating across the globe are well covered in literature (e.g. Alizadeh 2017; March 2018; Appio et al. 2019). Yet, several limitations deserve emphasis. First, with case studies dominating scholarship, many scholars have chosen atypical examples for analysis (Kitchin 2015). Moreover, with many studies based on accounts from a small number of cases, the subjective claims of scholars might not be generalisable and accurately reflecting broader trends (Mora et al. 2019). Addressing this limitation, several studies (Alizadeh 2017; Ruhlandt 2018; Joss 2019) have recently attempted to identify wider trends across large numbers of smart cities through literature reviews or macro-level analyses. However, few studies have mixed quantitative and qualitative methods (e.g. Ingwersen and Serrano-López 2018; Yarime and Karlsson 2018; Min et al. 2019) to systematically identify core development areas emphasised in a representative sample of smart city research and projects in different countries.

Second, the smart city is a "glocal" phenomenon (Dameri 2019). That is, although there is a widely shared fundamental understanding about the dominant features of smart cities in global discourse, the objectives and implementation of individual projects are heavily influenced by local contexts and differing interpretations of smartness (Goodspeed 2015; Trencher and Karvonen 2019a; Wathne and Haarstad 2020). Thus, comparing experiences in different countries can reveal important insights into how smart cities are conceived and pursued in different geographies, providing inspiration or cues for further learning opportunities. However, the systematic comparison of experiences in two countries is still an emerging methodological agenda for smart city research.

Third, scholars have sharply critiqued the early generation of smart cities due to a narrow focus on technology diffusion and economic objectives at the expense of social considerations (Hollands 2008; Caragliu et al. 2011; Glasmeier and Christopherson 2015). Cognisant of these shortcomings, new technologies and models of stakeholder involvement are emerging (Angelidou 2015; Cardullo et al. 2019; Ferraris et al. 2020) as global smart city vendors expand their product portfolios and discourse to reflect more human-centric objectives (Crowley et al. 2016; McMillan 2016; De Waal and Dignum 2017). Thus, there is still a need to deepen knowledge on how on-the-ground practices over the past decade have influenced the nature of academic discourse on smart cities.

Responding to these cues, this study mixes a quantitative and qualitative approach to compare the state of smart city research and practices in Sweden and Japan. Our primary research objective is to determine the principal thematic areas featuring in academic discussions and smart city projects. More specifically, we ask: (1) What are the similarities and differences in the thematic areas that can be identified across smart city research in Sweden and Japan? (2) What are the implications of those similarities and differences for smart city research and practice in the two countries? Our specific approach is to examine a sample of almost 2,000 academic studies published between 2010 and 2019 using a combination of thematic mapping, based on semantic co-occurrence networks, and qualitative descriptions obtained from the sampled literature. By identifying the topical foci of smart city development in Sweden and Japan, this paper aims to stimulate ideas for future collaborations between researchers and practitioners both inside and outside these countries. The novelty of our approach lies in the combined quantitative and quantitative approach, enabling a comprehensive, objective and systematic review of trends in different countries.

As global leaders in smart city development, Sweden and Japan allow a meaningful comparison of recent discourse and practices. Both countries are home to numerous corporations selling smart city technologies and executing large-scale, cutting-edge projects. Governments in each country are also vigorously promoting smart city developments through industrial policy, funding schemes and dedicated councils (Premat 2016; Barrett et al. 2021). Supported projects encompass a wide spectrum of environmental, economic and social objectives implemented under varying cultural, political and geographical conditions. Comparing these two countries is thus expected to generate insights into the effect of specific country or regional conditions on discourse and practice.

In addition to on-the-ground activities and actual experiences, smart cities are driven by shared discourses about ideals, objectives and possibilities (Joss 2019; Sadowski and Bendor 2019). Comprised of empirical and theoretical studies from both academics and industry practitioners, the literature examined in this study provides an ideal opportunity to examine these discursive and practical dimensions. Furthermore, smart cities frequently involve interactions and partnerships between university researchers and practitioners in industry and government (Ardito 2019). Not only are practical experiences reflected in academic literature, but smart city developments can also be influenced by the intellectual, technological, and planning capacities of academic researchers. This understanding of co-evolution between research and societal practices is supported by multiple fields of literature. This includes university–industry technology transfer (Etzkowitz and Leydesdorff 2000; Geiger 2005; Philpott 2011), triple or quadruple helix models of collaboration that unite actors from academia, university, industry and the citizenry (Etzkowitz and Zhou 2006; Gupta et al. 2019), and the co-creation of urban sustainability between universities and society (Thompson Klein et al. 2001; Trencher 2014, 2017; Binder et al. 2015). Thus, scientific publications—inclusive of both theoretical and empirical studies—are a useful proxy for understanding the overall state of research and application in technological innovation domains, with smart cities being no exception.

The remaining sections proceed as follows. Section 2 briefly reviews the global literature to consider the diverse spectrum of possibilities discussed for the smart city, focusing on key technological components, vision and objectives, actors, and governance. Section 3 then presents our methods, highlighting their novelty relative to other studies. Findings from the analysis of smart city literature from Sweden and Japan are presented in Sect. 4. Finally, Sect. 5 summarises key conclusions and presents implications for practice and research.

Background: the plurality of technologies, objectives, practices, and actors in smart cities

Before comparing the principal thematic foci of research from Sweden and Japan, this section firstly examines the spectrum of contrasting interpretations and framings of the smart city discussed in global literature. While an exhaustive review is beyond the scope of this paper, several studies (e.g. Dameri 2019; Joss 2019; Trencher 2019) indicate the following four perspectives are particularly useful for teasing out the wide gamut of imaginings and practices described in smart city scholarship: (1) basic technological components, (2) focus of vision and objectives, (3) principal actors, and (4) governance styles. In conducting this summary, our purpose is to illustrate the vast diversity by which the generic concept of a "smart city" is conceptualised and materialised around the globe. We also expect some of this variation to emerge in our subsequent analysis of Sweden and Japan.

Basic technological components

Amidst the diversity of specific terms and conceptions describing the quintessential components of the smart city, three dimensions are frequently emphasised in literature: technological, social and physical/infrastructural (Angelidou 2014; Neirotti 2014; Appio et al. 2019; Dameri 2019). The technological dimension encompasses both hard and soft aspects. Consisting of digital hardware and data-producing devices, the former often includes internet connected sensors embedded in the environment or worn by users, smart meters, smart grids, tablets, electric or autonomous vehicles, etc. Encompassing digital processes, the soft dimension includes data production and analytics, communication between devices, software, such as smart phone apps, and integrated or automated management and decision-making platforms (e.g. for optimising traffic flows). The social dimension concerns human actors and their various activities related to governance, economic, leisure, etc. Finally, the physical/infrastructural dimension includes the built environment (e.g. buildings, housing etc.), transport and infrastructure networks (e.g. water, waste, sewerage, road, energy, etc.) as well as the natural environment. The value added by smart city is the ability to connect these three dimensions with digital information flows in a way that enhances efficiency, innovation, intelligence and sustainability (Martin 2019; Nyberg and Yarime 2017).

The level of emphasis afforded to particular technologies provides an important opportunity for variation. One camp of scholarship paints smart cities as technologically sophisticated and futuristic. Here, urban activity is driven by a human-less mesh of digital artefacts, automation and the real-time production and analysis of big data (Kitchin 2014; March 2018; Sadowski and Bendor 2019). Yet, the level of complexity and dependence on technology and data can vary highly across cities. Some cities (e.g. Rio de Janeiro, London, Dublin and Stockholm) are portrayed to emphasise automation and decision-making driven by real-time data streams (Kitchin 2014; Kitchin et al. 2015; Kourtit and Nijkamp 2018). Yet, innovation in smart cities can also involve experimentation with relatively unsophisticated technological arrangements like smart tablets or apps (Trencher and Karvonen 2019b). Thus, what is considered "smart" and innovative in one location might not be elsewhere.

Vision and objectives

The imaginings and ambitions embedded in overarching narratives, policies and projects (Martin et al. 2018; Sadowski and Bendor 2019) are another important variable in the smart city. One model highlighted in literature is that conceived and pursued from a techno-economic perspective (March 2018; Sadowski and Bendor 2019). This places emphasis on stimulating economic activity, raising material prosperity and mitigating environmental problems through the testing and deployment of smart technologies (Joss 2019). Several existing cities, such as Songdo, Masdar, Hong Kong, San Francisco and Rio de Janeiro, are reported (Angelidou 2014; Cugurullo 2018; León and Rosen 2020) to exemplify this model.

Smart cities driven by narrow technological and economic objectives have dominated practices to date (Alizadeh 2017), meeting with heavy criticism. By promoting technology and data as the most desirable tools for advancing sustainability, improving the quality of life, and overcoming social challenges, techno-centric approaches are accused of fostering technological determinism (March 2018; León and Rosen 2020). This can risk focusing limited governance resources on low hanging fruit such as environmental problems suited to intervention with new technologies or infrastructure (e.g. traffic congestion or energy efficiency) while neglecting complex human issues that are relatively more difficult to tackle with techno-centric solutions (e.g. citizen empowerment, social cohesion, distribution of wealth etc.) (Kitchin 2015; Sadowski and Bendor 2019). Techno-economic aspirations may also exasperate inequality since opportunities to live in smart cities and consume cutting-edge technologies and services may not be evenly distributed (Angelidou 2015). Smart technologies per se are not necessarily critiqued. Rather, problems are raised when technologies are propagated without adequate consideration of the public values and societal purposes served (Glasmeier and Christopherson 2015; Hollands 2015; Trencher 2019).

A contrasting storyline portrays a human-centric city focused on citizen needs, social issues and governance (Baccarne 2014; Cardullo and Kitchin 2019). This model emphasises improving human capital and well-being through better governance (Ferraris et al. 2020). Although innovation can facilitate this, technology is put at the service of residents rather than the reverse (Angelidou 2014). Attention thus shifts from the supply of technology towards understanding endogenous social problems and how novel socio-technical configurations can address these and improve resident well-being. Public health and aged care are notable examples of growing interest in the human-centred applications of smart technologies (Trencher and Karvonen 2019b; Woods 2020). Although widely normalised, the people-centric model also faces problems, most particularly regarding the collection and use of sensitive personal data (McMillan 2017).

Principal actors

The composition of actors spearheading the design and implementation of smart cities provides another opportunity for divergent discourse and practices. The role of large corporations (Alizadeh 2017; Sadowski and Bendor 2019) and universities (Anttila and Jussila 2018; Appio et al. 2019) is frequently discussed. Both are important actors since they can provide innovative technologies, creativity and planning knowhow that may lack in government. Within this pair of innovation actors, the role of corporations is often critiqued based on concerns that granting excessive agency to private firms may propagate for-profit aspirations in place of collective values (Hollands 2015; March 2018; Trencher and Karvonen 2019a). This criticism is frequently directed at cases of smart city development shaped by powerful, incumbent firms with vested interests in particular technological configurations, framings of social issues or the privatisation of public services (León and Rosen 2020). As the principal provider of public services, municipalities are therefore crucial actors. While they can play an essential mediating role between citizens and corporations by aligning externally shaped projects with local needs (Tomor 2019), municipalities have been critiqued for handing over too much authority to corporations when designing and managing cities (León and Rosen 2020). Another variable for smart city projects concerns the degree of citizen participation (Vanolo 2016). When actively engaged in planning and problem-solving, citizens can function as co-creators by providing novel ideas, problem framings and solutions (de Lange and de Waal 2013). Governments are expected to facilitate this process through a commitment to openness and sharing data to the public (Ferraris et al. 2020). Smart technologies thus harbour rich potential to stimulate novel forms of inclusive governance. Yet, by narrowly viewing citizens as passive end-users or consumers of technology (Martin et al. 2018), many smart cities to date have failed to tap into their creativity and governance enhancing potential.

Governance style

Variation can also occur around differing models of governance. Top-down and bottom–up approaches are distinguished in literature (Dameri 2019; Trencher 2019). Yet, hybrid models—or cities that evolve from one paradigm to another—are also reported (e.g. Capdevila and Zarlenga 2015; Kummitha and Crutzen 2017). In the top–down model, government and corporations spearhead the design and implementation of projects, leaving scant room for involving citizens (Hollands 2015). Increasing tendencies to remove the human from decision-making via algorithms, data and automation can also re-enforce technocratic and managerial-style governance in cities (Kitchin et al. 2015). In the contrasting bottom–up model, decision-making is decentralised, fostering ample opportunities to engage residents and diverse stakeholders into project design and implementation (Tomor 2019). This can promote social equity by allowing a more inclusive representation of values and interests in decision-making (Cardullo et al. 2019). Yet, how to enrich citizenship with technology and data remains an unresolved challenge in the smart city (Cardullo and Kitchin 2019).

Methods

Underlying assumptions, approach and novelty

This study departs from the assumption that scientific literature is a valuable proxy for depicting the state of technological development and high-level discourse shared by researcher and practitioner communities in a particular country. To capture and compare the state of smart city discussions and practices in Sweden and Japan, our basic approach was to conduct a systematic literature review of journal articles, books, chapters and conference proceedings published from 2010 to 2019. Based on abstracts, titles and keywords, we build and analyse semantic co-occurrence networks—a form of content analysis—to identify and compare the principal themes of research and practice emphasised in each country. We then supplement this analysis by drawing on the full texts of relevant papers from each sample to explore the identified co-occurring themes in more depth.

Our approach builds on previous studies employing co-occurrence networks to analyse trends in the research and practices of smart cities and sustainability (Cheng 2018; Yarime and Karlsson 2018; Min et al. 2019; Mora et al. 2019). Our study, however, is novel in several regards. First, previous studies have not used this method for the explicit objective of comparing research and practice in two countries. Second, by including academic and non-peer-reviewed publications from companies and research institutes, our study captures trends in both research and practice. Third, by examining abstracts, our study provides a finer-grained analysis than previous literature examining key words only.

Case selection

Sweden and Japan were selected for comparison due to similar socio-economic conditions as well as cutting-edge research and smart city practices encompassing diverse environmental, economic and social objectives. Both Sweden and Japan are economically prosperous and global leaders in technological innovation and information technology. In 2019, Japan's gross domestic product was $43,236 per capita (expressed as purchasing power parity) in comparison to $55,820 in Sweden (World Bank 2020). The "Global Innovation Index 2020" (Dutta et al. 2020) ranks Japan as 10th in the world and Sweden 13th for overall performance in the availability of infrastructure for ICTs. Both countries are also home to renowned smart city vendors with international project portfolios. In Japan, these include Hitachi, NEC, NTT and Fujitsu, along with Ericsson, Telia, Scania and ABB in Sweden. Moreover, both countries are supporting a significant number of thriving smart city projects at various scales. For instance, Sweden is home to smart city projects in the capital Stockholm (Hollands 2015; Angelidou 2016) as well as large or regional principal cities, such as Gothenburg (Brorström et al. 2018), Malmö, and Umeå (Premat 2016). Japan is also home to major citywide projects in Yokohama, Kitakyushu, Keihanna and Toyota (Li 2018; Suwa 2020) in addition to regional cities, such as Kashiwa-no-ha near Tokyo (Trencher and Karvonen 2019b) and Aizuwakamatsu in Fukushima (Trencher 2019). National governments in both countries have prioritised smart city development when formulating various national funding programmes and industrial policies around economic, technological and environmental issues (Premat 2016; DeWit 2018). Notable examples include Japan's vision of a "Society 5.0" in its "5th Science and Technology Basic Plan", published in 2016[1] (Deguchi 2020), and the "Super Cities" program, announced in late-2020 (Barrett et al. 2021).[2] In Sweden, the "Strategic Innovation Agenda for Smart Sustainable Cities in Sweden",[3] was established in 2015 to promote joint research and actions across national research institutes, public agencies, local governments and enterprises (SSC Sweden 2015). Propelled by such supportive conditions, smart city developments have proliferated across Sweden and Japan, featuring heavily in academic literature. Analysing this rich archive of data thus reveals core trends in research, practices and discourses in two countries at the forefront of smart cities development.

Co-occurrence network analysis

Co-occurrence networks for each country were built by analysing the abstracts, keywords and titles of the sampled publications. By depicting the frequency by which a pair of words mutually appear across texts (i.e. co-occur), this method of content analysis enables the visualisation of knowledge structures and recurring semantic patterns in multiple sources (Leetaru 2012; Armborst 2017). Compared with other content analysis techniques, such as document clustering, hierarchical clustering or topic extraction, co-occurrence network analysis enables a finer-grained depiction of association between topics, which is also assumed to exist in smart city research.

Co-occurrence graphs consist of three key elements: nodes, edges and sub-graphs. Nodes represent the extracted words from the text, edges show how the nodes relate at the two ends of the edge, and sub-graphs depict a group of

[1] Proposed by the Cabinet Office of Japan in the goal of tackling economic and social challenges while driving the development of science and technology, this vision calls for the integration of artificial intelligence, cyberspace and physical spaces to achieve a society where the creation and use of data and ICT services are ubiquitous and largely automated.

[2] Also formulated by the Cabinet Office, this funding and implementation program seeks to support the application of big-data, artificial intelligence and holistic smart city planning to tackle social problems such as health and aged care while improving education and government services as well as decarbonising transport and energy. Five city-scale projects are expected to be funded in 2021.

[3] Proposed by 27 stakeholders in academic institutions, enterprises, NGOs and public agencies, this initiative fixes shared concepts, visions and specific strategies for smart sustainable cities. Emphasis is made on collaborated research and innovation for empowering citizens and building sustainable, integrated urban infrastructure.

nodes that are strongly connected by edges. Although several approaches are possible when determining sub-graphs, we opted for the modularity method, thus defining boundaries to ensure that most edges remained inside the subgraph boundary, leaving few outside (Newman and Girvan 2004). Among several software options available, "KH Coder3" was chosen due to two advantages. First, since this software can process etymological differences and omit un-meaningful words (the, result, we, etc.), it is well suited to identifying semantic patterns (Luo et al. 2019). Second, KH Coder3 offers several options for rendering the co-occurrence visualizations (Higuchi 2016).

Our chosen method has both strengths and limitations. The main advantage of using co-occurrence network analysis for our study lies in its ability to systematically and objectively identify thematic trends from a vast body of literature, too voluminous for manual analysis. This satisfies the need for scientifically sound literature reviews to be systematic, explicit, and most importantly, *reproducible* (Caulley 2007). Conversely, however, by focusing only on abstracts, keywords and titles, full-body texts were not examined in the co-occurrence analysis. The main two reasons underpinning this decision relate to physical obstacles in obtaining access to all articles appearing in search results, and the lower conceptual clarity that would occur in the network visualisation if including entire body texts. This is because the frequency of important words would be reduced relative to abstracts, which tend to contain denser descriptions of key concepts with fewer words. Thus, when reporting findings, we overcome this limitation by drawing on the body text of relevant publications from each country's sample[4] to provide a deeper and qualitative analysis of key research discussions and practices occurring in each country.

Literature extraction and co-occurrence network construction

The sampled publications for both countries were identified through the Scopus database in September 2019 using the following search terms: *smart city, smart community*[5] or *smart grid.* Targeting the abstract, keywords and titles of literature, search strings were lemmatised to include plural forms (e.g. "city" and "cities"). To integrate discussions from both research and practice, we examined diverse literature published in English during the period 2010–2019. This included conference proceedings, journal papers, books and book chapters, and trade publications. A total of 1,946 relevant studies were extracted and analysed (see Electronic Supplementary Material S1). The parameter AFFILCOUNTRY in Scopus was used to specify author affiliations, limiting search results to publications where the affiliation address for any listed author included either Sweden or Japan.

Ensuing from this method, the respective samples include publications where: (1) the primary author is not affiliated to Sweden or Japan, or (2) the empirical or theoretical scope is not confined to either country. We chose to retain these studies for three reasons. First, the bulk of publications in our sample is written by a first author belonging to a university, company or government agency located in either Japan or Sweden. Second, the majority of studies in each country's sample share a meaningful degree of focus on that country. Third, even for publications focused on smart cities developments outside Japan and Sweden, at least one author is affiliated with an institution in either country. We thus assume that some of the key topical, discursive or technological trends in Japan or Sweden would still reflect to some extent in these publications.

The results of the literature extraction are shown in Table 1. Considering that Sweden's population is less than one-tenth of Japan's (around 10 million in 2019 compared to 126 million), the identification of 615 relevant papers against 1331 in Japan demonstrates a much higher presence of smart-city-related publications in English per capita.

For both countries, the bulk of publications is authored by university researchers. In Japan, however, literature published by companies makes up a larger share relative to Sweden. Companies particularly active in publishing in Sweden included, for example, ABB (an automation company), Vattenfall (a power utility) and Ericsson (a telecommunications company). In Japan, private firms include NTT (a telecommunications company), Hitachi and Toshiba (manufacturing companies), as well as NEC and Fujitsu (IT and electronics companies). In terms of document type, the sample of both countries is similarly composed. Specifically, conference papers make up more than half of extracted publications, with journal articles comprising approximately one-third. Incidentally, there were only 4 publications where one or more members were affiliated to both Swedish and Japanese institutions. Considering the nearly 2,000 publications examined, this indicates a weak degree of research interactions between the two countries.

When building the co-occurrence network visualisations for each country, the number of edges (i.e. links between nodes) was adjusted so that both countries contain roughly the same number of nodes. Adhering to common best

[4] In the case where publications from outside either country's sample are cited in the findings, these are marked with "see" in the citation bracket (e.g. see Author 2019).

[5] In building the Japanese network it was important to include "smart community" in addition to "smart city". This is because representative smart city projects funded by the national government, often targeting residential areas, are labelled "smart communities" (Granier and Kudo 2016).

Table 1 Summary of publications extracted

	Sweden	Japan
Number extracted	615	1331
Author affiliation		
University	83%	72%
Research institution	6%	9%
Company	11%	19%
Document type[a]		
Journal articles	33%	32%
Books and book chapters	4%	3%
Conference papers	58%	60%
Reviews	2%	3%
Other	3%	2%

[a]These follow the categories of the Scopus database. "Other" includes editorials, letters, data papers, erratum, notes and undefined

practices for this method (Murao and Sakaba 2016), this involved a reiterative process of repeatedly changing the number of edges in each country's network visualisation until a comparable volume of nodes emerged. This process helps ensure the comparability of results, since the nodes with a similarly high degree of relevance to the topic of interest (i.e. smart city) are depicted.

Results and discussion

Co-occurrence networks for both countries

Figures 1 and 2 depict the co-occurrence networks for Swedish and Japanese publications, respectively. We define the "Swedish network" as that shown in Fig. 1 and the "Japanese network" as that shown in Fig. 2. As mentioned, the Swedish network shows the co-occurrence of semantic themes detected in the abstracts, keywords and titles of literature from which at least one author is affiliated to a Swedish institution, and likewise for the Japanese network. The colours of the nodes (appearing as circles) are automatically given by the KH Coder software and differ between Figs. 1 and 2, even for the same topic. A simple numbering system (shown in the red, blue and green boxes) was thus devised to facilitate the identification of similar and unique topics: numbers 1–10 in red boxes depict topics co-existing in both networks; 11–16 in blue boxes indicate those existing only in the Swedish network, and 17–25 in green boxes depict those observed only in the Japanese network. Each figure also includes information on parameters, such as coefficients, frequency and density information. Co-efficient values indicate the degree of relevance for edges (shown in lines), with darker lines showing a higher co-efficiency. Frequency reflects the number of times each word appears in the sampled literature, with larger circles indicating a higher frequency.

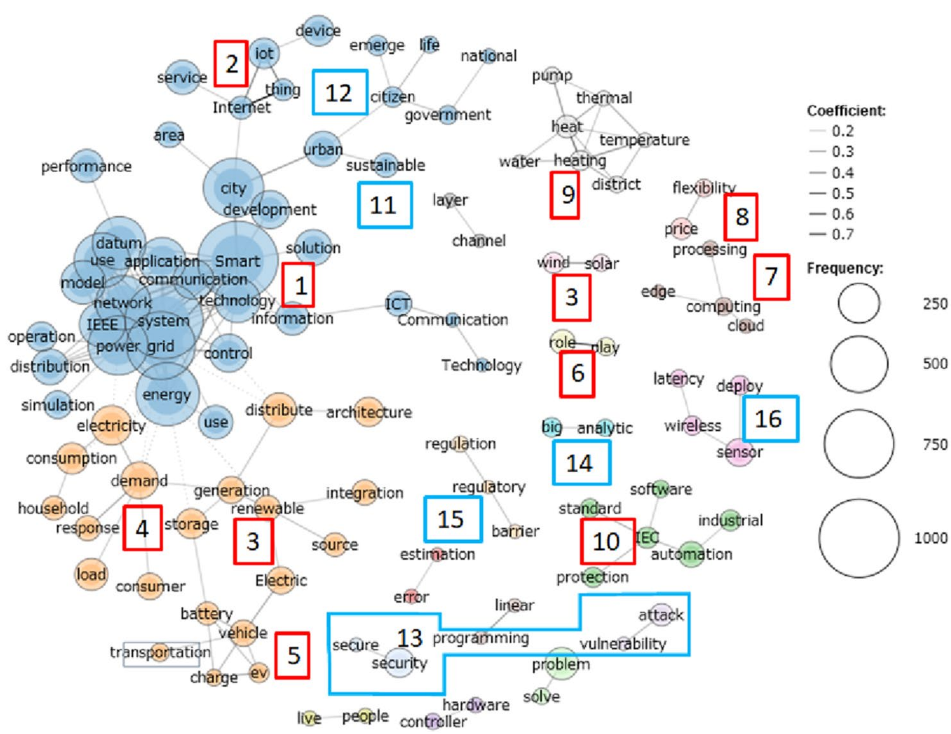

Fig. 1 The Swedish network: co-occurring words in publications with a Swedish affiliation. Note: red boxes show themes present in both country's network while blue boxes show those unique to the Swedish network. Figure comprised of 107 nodes and 170 edges

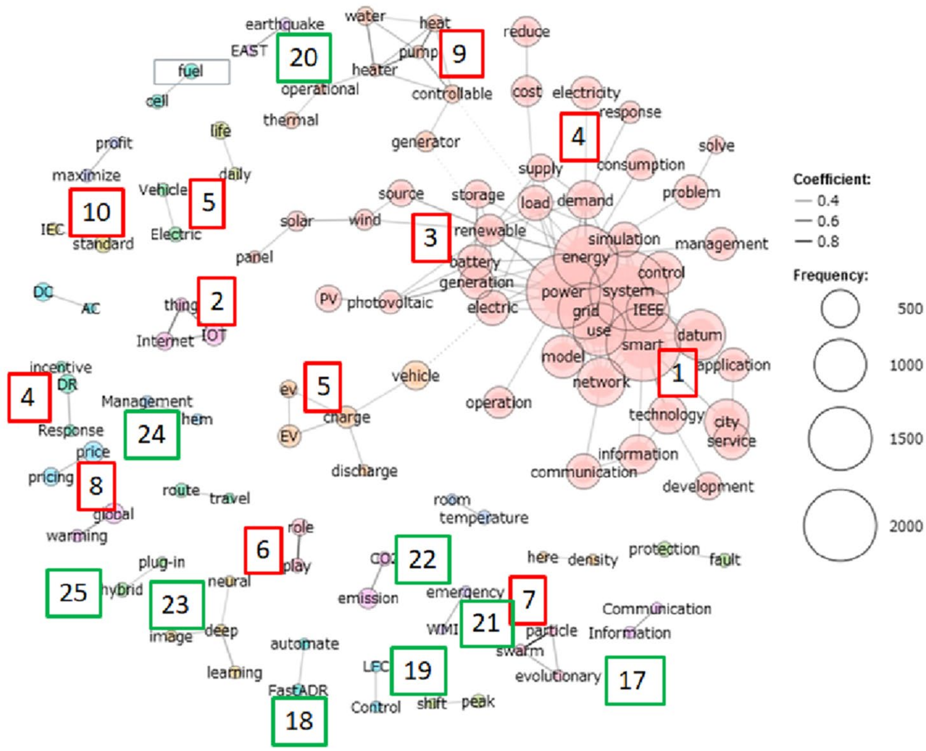

Fig. 2 The Japanese network: co-occurring words in publications with a Japanese affiliation. Note: red boxes show themes present in both country's network while green boxes show those unique to the Japanese network. Figure comprised 112 nodes, and 165 edges

Table 2 Individual topics present in both networks

Topic number[a]	Topic
1	Smart grid core components (smart system, energy, grid, power, datum, model, technology, city, network, application, information and communication)
2	Internet of Things (IoT)
3	Renewable energy resources and electricity storage
4	Demand response
5	Electric vehicles
6	Roles of stakeholders
7	Computation methods
8	Electricity pricing
9	Heat pumps
10	IEC standards (61599, 61850)

[a]Numbers correspond with those topics marked by red boxes in Figs. 1 and 2

Similarities in Swedish and Japanese networks

The specific topics featuring heavily in both Japan's and Sweden's network are summarised in Table 2. As reflected by the size of circles, results indicate an overwhelming thematic focus in both countries on the technological dimensions of smart cities (topic 1, 2, 3, 5, 7, 9). In contrast, socially oriented themes, such as the roles of stakeholders (topic 6) or discussions combining both social and technical dimensions (topic 4, 8, 10), occur far less frequently in the sampled literature.

Technological development

In terms of the most prominent areas of technological research and practice, as reflected by its large size and tight clustering of themes, topic 1 is particularly dominant in each country's network. This thematic cluster is composed of terms such as smart, system, energy, grid, power, datum, model, technology, city, network, application, information and communication. Specific and recurring topics include distributed or local generation systems, supply and demand management, battery storage, electric vehicles, heat pumps, household appliances, ICTs, and security issues (Strasser 2015; Chisaka and Nakagawa 2016; Nadeem et al. 2019a, b). In addition, both countries feature sites for demonstrating the integration of locally distributed energy systems involving the active participation of households (Nakamura and Kamitsukasa 2016; Nilsson 2018).

Interestingly, as represented in topic 9, heat pumps are researched in both countries. However, the "district" node appears only in Sweden's network, where district heating is common. District heating in Sweden is discussed in relation to smart grids through so-called fourth-generation district heating (Schweiger et al. 2017; Lund et al. 2018). This technology aims to integrate district heating sourced principally from renewable sources (e.g. biomass) with energy-efficient buildings and smart energy systems, such as electricity, gas or thermal grids. Requiring both institutional and technological integration, the deployment of smart district heating must grapple with a host of regulatory, market and geographical barriers (Lund et al. 2018).

Another common theme in both countries concerns International Electrotechnical Commission (IEC) standards (topic 10). Specific items discussed in literature include the IEC standard 61499 for distributed control systems or the IEC standard 61850 for smart grids. Largely from engineering fields and technical in nature, discussions on IEC standards are largely concerned with how data quality protocols for integrated and automated electrical grids can enhance flexibility and stability by improving communication and interoperability across smart devices (Eriksson 2015; Strasser 2015; Wu et al. 2018a). In Japan, security and performance issues around IEC standards for smart grid communication are actively discussed and researched in relation to areas such as vehicle-to-grid or virtual power plants (Senke et al. 2012; Nadeem et al. 2019a, b; Ustun et al. 2019). Meanwhile, Sweden is more inclined to discussing models of power distribution grids and substation automation system under these standards (Yang et al. 2017; Drozdov et al. 2018).

Social objectives

Relative to technology, socially oriented topics, such as governance, stakeholder participation and societal problem-solving, emerge far less frequently. Furthermore, discussions on issues such as social equity, social justice, inclusiveness and human capital, are absent. The two main social topics to emerge in both country's network consist of co-occurrences between "role" and "play" (topic 6) and "demand" and "response" (topic 4). Closer inspection of relevant examples in Swedish publications reveals that a handful of researchers have examined the role of differing stakeholders in various smart city activities. These include the role of residents in consuming and producing energy in smart energy systems (Renström 2019), the role of the university as a test-bed for cutting-edge urban innovation, (Karvonen et al. 2018), and the role of city governments in handling data produced in the smart city (McMillan 2016). For Japan, the roles of various social actors are also mentioned in some publications, but to a limited degree. DeWit (2018) documented the role of political entrepreneurs and actors bridging academia and national government in the field of disaster resilience and energy. Nyberg and Yarime (2017) focus on interactions between actors involved in envisioning and implementing smart cities. Yet, the focus is on corporate actors rather than citizens. Yarime (2017) focuses on academic actors, calling for sustainability science communities to take a role in sharing data for smart cities. Meanwhile, the role of local government and citizen involvement is emphasised by a handful of studies (Trencher 2019). However, in Japanese research, attention to this topic is significantly less than in Sweden.

As a final observation, in both country's network the absence of a distinct cluster oriented around the economic functions of the smart city is noteworthy. This is somewhat surprising given the many criticisms identified in the literature review regarding the tendency for smart cities to over prioritise economic objectives.

Health and well-being

Although not visible in either country's co-occurrence network, closer analysis of the sampled literature revealed that several researchers in Japan and Sweden have focused on the topic of health and citizen well-being when discussing possibilities for broadening the societal and sustainability objectives of smart cities. In Japan, especially, interest in this topic is driven by concerns related to rapid population aging (Trencher and Karvonen 2019a). Researchers from Japan (Hayashi 2011; Vadgama 2011; Yagi 2014) and Sweden (Markendahl et al. 2017; Gams 2019) have discussed how base technologies commonly used in smart cities—e.g. smart grids, sensors, data analytics software and automated decision-making—can be applied to areas such as health care and home medical treatment. Specific cases of such technologies being adopted in both countries are also discussed (McKay et al. 2015; Tokoro 2017). In Japan, initiatives in the Kashiwa-no-ha smart city are highlighted by several studies. Located on the outskirts of Tokyo, this new-build city focuses on smart health as the core of its socially oriented agenda, alongside ambitions of environmental protection and new industry creation (Taniguchi et al. 2014; Minemoto et al. 2016; Barrett et al. 2021). Concrete initiatives have involved experiments with the visualisation of health data collected from wearable devices and a community health centre for promoting preventative health and active lifestyles (Trencher and Karvonen 2019b). Meanwhile, Swedish researchers (Ek 2018) have focused on

Table 3 Co-occurring topics unique to either country's network

Sweden		Japan	
Topic number[a]	Topic	Topic number	Topic
11	Sustainable, urban	17	Particle swarm optimization[b]
12	Government, citizen, national	18	FastADR (Automated Demand Response)[c]
13	Attack, vulnerability, secure, security	19	Load Frequency Control (LFC)
14	Big, analytic	20	(Great) East (Japan) Earthquake
15	Regulation, barrier	21	Wireless Multihop Infrastructure (WMI)
16	Wireless, sensor, deploy, latency	22	CO_2 emissions
		23	Neural network, deep learning
		24	HEMS (Home Energy Management System)
		25	Hybrid

[a]Numbers for Sweden and Japan correspond with topics marked by blue and green boxes in Figs. 1 and 2

[b]Particle swarm optimization refers to a type of meta-heuristics algorithm using artificial intelligence to optimise energy networks

[c]FastADR refers to the automation and acceleration of response to demand fluctuations in building energy management and power grids

Stockholm to examine the effectiveness of a public health experiment using a smart phone application to increase the physical activity of residents by promoting active transportation (e.g. walking and cycling). While the scale of these discussions is dwarfed by other technological issues, such as power grids and energy, the area of resident health and well-being indicates an emerging pathway by which some researchers and practitioners in both countries have sought to tie smart technologies to socially relevant issues.

Differences between Swedish and Japanese networks

The unique co-occurring topics appearing only in the Swedish or Japanese network are shown in Table 3.

Sustainability in conceptualisations of smart cities

One notable difference concerns the varied interpretations of "smart city" in each country. While "sustainability" is connected to "urban" and "cities" in the Swedish network (topic number 11), integrated discussions of this nature are absent in the Japanese network.

Regarding the higher level of interest in this topic in Sweden, the long history of state and societal engagement in developing and operationalising the concept of sustainable development (see Ehnert 2018; Lidskog and Elander 2012) has possibly influenced the tendency for the goals of smart cities to be conceived around the broader pillars of sustainability (see Bibri and Krogstie 2020; see Parks 2020). This holistic conceptualisation and implementation of the "smart sustainable city" is discussed in several studies (Höjer and Wangel 2014; Parks and Rohracher 2019). Meanwhile, earlier discussions of "sustainable cities" in Europe are reported to have expanded to integrate features of "smart cities" (Granath and Axelsson 2014; Martin et al. 2018; Parks and Rohracher 2019).

Indeed, out of the Swedish literature extracted for analysis, 2.4% (15 out of 615) include varying combinations of "sustainable" and "smart" in article abstracts in contrast to 0.38% (5 out of 1331) in the Japanese literature. The 15 publications in the Swedish network are largely from social science fields, such as urban studies and geography. Many examine novel initiatives for tackling social issues, such as integrating marginalised and culturally diverse communities into sustainable food production (Heitlinger et al. 2018, 2019), or incorporating measures of liveability into environmentally focused datasets for urban decision-making (Kourtit and Nijkamp 2018). Meanwhile, Martin et al. (2018) provide a notable example of a study focused on identifying problems in past smart city projects in Europe and North America. Much criticism is extended against the tendency for smart cities to reinforce neoliberal economic objectives that privilege affluent populations and promote consumerist culture while neglecting social and environmental sustainability issues. Similarly, Kramers (2014) argue that the use of ICTs in cities does not necessarily promote environmental sustainability per se, proposing that the "smart sustainable city" concept be used to distinguish cities using smart technologies to achieve sustainability goals. If observing contemporary smart city projects in Sweden, this dual framing of sustainability and digital smartness is visible in the Stockholm Royal Seaport's "smart and sustainable city" (Kramers 2014; Shahrokni et al. 2015) and, similarly, the City of Gothenburg's strategy as "smart solutions for sustainable cities". Meanwhile, Malmö and Örebro are also described as "climate smart cities" (Granberg 2018; Parks 2018).

Although this integration of smart and sustainable is not present to the same extent in Japan, a limited number of researchers have taken up this framing. Out of the five Japanese studies related to "sustainable smart" cities, one (Bhattacharya 2018) constructs an index for assessing sustainable smart city outcomes through four pillars—economic, environmental, social and human development—for use in developing countries. Another (Yarime 2017) calls for more institutional arrangements to facilitate the open sharing of diverse forms of data in smart cities with relevance to environmental, social and economic activities. For the other three also mentioning "sustainable" in conceptions of smart cities, only one provides a holistic framing of smart city services (Sakurai and Kokuryo 2018) In this study, the authors highlight the integration of initiatives to promote wellness, social networks and community solidarity when discussing the various projects making up the sustainable smart town implemented in Fujisawa City, in outer Tokyo.

From this brief comparison, it can be concluded that in Sweden—and indeed in Europe—conceptions and materialisations of the smart city are tightly rooted to the historically more established framing of a "sustainable city", now adapted to the dissemination of new digital technologies (Parks and Rohracher 2019). In Japan, however, the goals of smart city projects are typically shaped by the private companies leading their conception and implementation (Nyberg and Yarime 2017). Though these goals can align with those of the broader concept of sustainable development, their scope and attention to broader social objectives is often limited by the intellectual and technological capacities of private firms and their specific product portfolios (e.g. smart meters and demand-side visualisations of energy consumption, etc.) (Sakurai and Kokuryo 2018).

Participation of local government and citizens

As a further difference, topic 12 in Fig. 1 reveals a thematic co-occurrence in the Swedish network around "government" and "citizen" that does not feature in the Japanese counterpart.

Closer inspection of the relevant literature for Sweden (largely coming from social science fields) reveals that discussions dealing with government are mostly focused on local municipalities. Emphasis is placed on their role as active drivers of low-carbon transitions (Granberg 2018) or the institutional changes that have occurred through smart energy governance with other stakeholders (Parks 2018). Additionally, in Europe (especially in Scandinavian countries), there is high interest in the research and implementation of urban living lab projects, where technological and social innovation is co-produced though experimentation involving local governments, citizens and companies. The Swedish literature also reflects this trend. Several studies discuss urban living labs (Krogstie 2013; Ståhlbröst et al. 2015; Palgan et al. 2018) implemented in cities, such as Kiruna, Malmö and Stockholm, as well as university campuses (Renström 2019). Scholars have been particularly attentive towards the role of local governments in such initiatives (Palgan et al. 2018). Literature related to the theme of "citizen" also discusses initiatives where citizens co-design cities with other actors (Heitlinger et al. 2019) and how digital technologies can be levered as a tool to promote collaborative governance and "smart citizenship" (Atif et al. 2019; de Lange et al. 2019). Living labs also feature in these discussions as one of the emerging methods of citizen engagement and empowerment (Martin et al. 2018). While the literature from the Swedish network often frames the local government a strong actor in urban development, NGOs are also reported to be playing active roles, especially in Stockholm (see Ehnert 2018).

In the Japanese network, though the role of local governments in coordinating smart city projects is recognised (see Mah et al. 2013; Tokoro 2017; Suwa 2020), research concerned with co-creation between citizens, local governments and academia is much less prominent. Trencher (2019) has focused on the atypical case of Aizuwakamatsu Smart City in Fukushima, emphasising how citizens are conceived as core actors for co-creating solutions to various social issues affecting their livelihood. Overall, however, research describing initiatives to promote the co-design of smart city projects between citizens and local governments is scarce. This tendency corresponds with arguments by Granier and Kudo (2016). Examining one of Japan's smart community projects, the authors contend that even in cases where citizen participation is mentioned in project objectives, their role is passive and mostly limited to the "co-production" of distributed renewable energy or demonstrating demand-side behavioural change in response to the introduction of smart technologies. As one example, in the Kitakyushu Smart Community (see Sect. 3.2), municipality officials have allegedly viewed the chief purpose of citizen participation as enhancing the social acceptance of policy (Granier and Kudo 2016). This framing suggests that citizens are not regarded as possessing the necessary competences for involvement in policy design or that citizens lack interest in such a role (see Dewit 2013). This view is supported by Granier and Kudo (2016) who argue that in terms of societal characteristics, Japanese are typically passive about government policies and reluctant to take the initiative in influencing their formulation. Our analysis suggests, however, that claims of weak citizen engagement do not apply to *all* Japanese smart cities, since newer studies emphasise a recent increase in participatory governance models (DeWit 2018; see Barrett et al. 2021).

Regarding the comparative lack of Japanese research on the role of local government, two reasons might partly explain this. First, it is often the case that large national corporations rather than local municipalities are the central drivers of smart city projects (Nyberg and Yarime 2017; Yarime and Karlsson 2018). Second, with the vast majority of the Japanese sample coming from engineering related fields, it is understandable that interest in smart cities is centered more on technological development rather than governance.

Contextually influenced interpretations of vulnerability towards hazards

Publications concerned with "secure", "security", "attack", "vulnerability", "resilience" and so forth emerged in both country's network. Yet there are distinct divergences regarding the precise area of interest. In the Swedish network, discussions are mostly focused on the security of grids and communications infrastructure towards malicious anthropological threats such as cyber attacks (topic 13). In Japan, however, thematically corresponding discussions are focused on natural hazards such as earthquakes (topic 20). Contextual conditions in each country appear to explain this difference.

In the Swedish network, research about malicious cyber threats is carried out prominently (Teixeira 2015; Wu et al. 2018b; Pan et al. 2019). Concretely, 5.0% (31 out of 615) of publications in the Swedish network include either the word "attack" or "vulnerability". This compares to only 1.7% (23 out of 1331 articles) in the Japanese network. Cyber-attacks are a growing concern because of the heavier reliance in smart cities on IT infrastructures and standardised communication protocols in electricity transmission systems. In addition to Sweden, cyber-attacks are a pressing issue across Europe after continental power grids experienced assaults, such as Stuxnet[6] or Dragonfly[7] (Teixeira 2015). The importance of protecting Europe's continental grid is now greater than ever as electricity generation becomes increasingly decentralised, due to the growth of renewables, and as countries look to power imported from elsewhere to back up local systems when supply falls below demand (see Fulli et al. 2016; see Ilves 2016). As government funding in both Europe and Sweden places high priority on supporting the development and application of technologies to protect this grid from security threats, such as cyber attacks, several solutions are discussed. These include preventative measures such as the simulation of vulnerability to attacks by injecting false data into power transmission systems (Hendrickx 2015; Pan et al. 2019) and the development and deployment of software applications to boost the resilience of interlinked power grid and communication infrastructures (Kintzler et al. 2018).

In contrast to the high interest in protecting against malicious attacks of anthropogenic origin in the Swedish network, the Japanese network reveals more attention to natural disasters. This particularly relates to earthquakes (topic 20), a thematic focus absent in Sweden's network. Several studies in the Japanese network (Fujiwara et al. 2015; DeWit 2018; see Barrett et al. 2021) emphasise that the Great East Japan Earthquake of 2011 was a major contextual trigger for the intense interest with energy optimisation and resilience in Japanese smart cities. Following the nationwide idling of baseload nuclear power in reaction to the explosion at the Fukushima Daiichi Nuclear Power Plant, the eastern part of Japan (particularly the Tokyo Metropolitan area) experienced rolling blackouts and government requests to industry to cut down electricity use, since 31% of electricity in Japan was supplied by nuclear power plants at the time (see Hayashi and Hughes 2013). In addition, communication infrastructures were also severely damaged by the earthquake and tsunami, hampering rescue operation efforts. In addition to earthquakes, this series of incidents has urged researchers to tackle issues related to the resilience and breakdown of critical infrastructures during emergencies triggered by natural disasters, such as typhoons and floods (Fujinawa et al. 2015; Teng et al. 2017). Concretely, several researchers focus on efforts to reduce energy demand and dependence on national power grids through energy efficiency, micro-grids and distributed renewable energy production (Asano 2016; Nakamura and Kamitsukasa 2016; Kawamura 2017; Baba et al. 2019). In addition, resilience-boosting technologies such as wireless multi-hop infrastructure (topic 21) are frequently discussed in relation to power grids and communication infrastructures (Teng et al. 2017; Junjalearnvong et al. 2019). By transmitting information wirelessly in a network from the first node to then "hop" through several others, this technology offers a higher degree of resilience compared to conventional wireless communication protocols.

Smart grid regulation

Topic 15, unique to the Swedish network, depicts discussions focused on regulatory aspects of smart grids (Picciariello et al. 2015; Björkman et al. 2016; Fazlagic 2017; Parks and Wallsten 2019). This research is underpinned by views that current institutions are hampering efficient grid operation and the integration of distributed renewable

[6] This malware, discovered in 2010, was designed to infiltrate Siemens' SCADA product.

[7] This malware has repeatedly attacked the energy sector during the period 2011–2017, with cases concentrated in Spain, United States, France, Italy, Germany, Turkey and Poland.

energy (Parks and Wallsten 2019). The relative maturity of discussions on regulatory dimensions of smart grids in Sweden (Picciariello et al. 2015; Björkman et al. 2016; Fazlagic 2017) is likely explained by the early liberalisation of the domestic electricity generation market in 1996 and the establishment of authorities to regulate the behaviour of European electricity grid operators. Despite the maturity of Sweden's liberalised market for power generation, some see the distribution sector as excessively regulated and as a "monopoly" (Picciariello et al. 2015). Researchers have argued that regulations should be reformed to incentivise grid operators to integrate more sources of distributed generation and to increase the efficiency of grids, by decreasing transmission losses and the curtailment of renewables (Picciariello et al. 2015; Björkman et al. 2016; Fazlagic 2017). In Japan, however, such discussions are nascent. Not only did full liberalisation of the electricity generation market only occur after 2016, but tariffs are still regulated. Meanwhile, transmission and distribution are still controlled by regional monopolies. There are thus opportunities for Japan to draw lessons from the experiences of Sweden.

Big data and analytics

Results reveal a higher degree of interest in Sweden regarding "big data" and "analytics" (topic 14). Research considers this from both a technological and social perspective. Studies from computer science and engineering largely focus on technical issues, such as how to effectively and securely collect, manage and analyse big data (Hu and Vasilakos 2016; Bagheri et al. 2017; Osman 2019). The use of big data to monitor energy consumption and waste generation in Stockholm's Royal Seaport features in literature (Shahrokni et al. 2015). Although fewer, studies from social science fields reflect these developments by considering issues more related to the societal application of data analytic technologies. For example, Kourtit and Nijkamp (2018) propose a holistic urban navigation platform for measuring socio-economic and sustainability performance at the city-level. The authors stress the use of social indicators for improving well-being as an important goal of the smart city. Meanwhile, McMillan (2016) examine social acceptance and challenges encountered by European attempts to collect and disseminate citizen data.

Specific technological developments in Japan

In Japanese research, clusters of specific technologies standout, such as topics 17, 18, 19, 23, and 24. For example, topic 23 contains research examining themes such as "neural", "deep", "image" and "learning". One concrete area attracting interest is deep convolutional or recurring neural networks for image labelling. Driven by recent advances in artificial intelligence, the development and application of such systems is discussed in areas, such as pedestrian detection, mobility prediction and waste management (Hara et al. 2018; Liu and Shoji 2019; Mikami et al. 2019). As a concrete example, one team of researchers describes the development and demonstration of deep learning in the field of residential waste management in the Fujisawa smart city. Here, cameras and image processing technology seek to optimise the collection and sorting of residential garbage in trucks via automated counting and problem detection (Mikami et al. 2019).

Shown in topic 24, home energy management systems (HEMS) are implemented in most of the major smart city projects in Japan (Granier and Kudo 2016; Honda et al. 2017; DeWit 2018). HEMS allow the visualisation of household electricity consumption for residents through smart devices, such as wall panels, computers, tablets or smart phones, in addition to the remote control of lights and air-conditioning via the internet. HEMS technologies have been the subject of much investigation due to widely shared expectations they can provide cues for energy conservation during daily life or emergencies (Chatfield and Reddick 2016; DeWit 2018). Interestingly, while this technology ultimately concerns residents and behavioural change, there is a notable lack of any explicit association with users and behaviour in this cluster (topic 4). This differs to the Swedish network, where the "consumer" co-occurs with research in this area. Again, this points to an overall weaker degree of engagement with the social dimensions of smart technologies in Japan's network.

Conclusion

This study systematically and objectively compared the state of smart city research and practice in Sweden and Japan, identifying common, unique and underrepresented themes in each country's research network. Combining a co-occurrence network analysis of nearly 2,000 publications with a detailed reading of identified topics, we addressed a gap whereby no study until now had integrated quantitative and qualitative methods to systematically compare a large volume of smart city practices and discussions across two countries.

In terms of overlapping trends, discussions around specific technologies, such as ICTs, Internet of Things, energy-related artefacts, EVs, etc., dominate in both countries. Thus, there is much consistency between the technological components making up smart cities in Sweden and Japan. Conversely, discussion on social issues, such as human capital, governance, citizen participation, equity and human interaction with technologies, is modest if comparing to the overwhelming interest with technological issues.

Attention to these social dimensions was observed to be relatively lower in Japan. This difference appears to be largely influenced by the two different approaches to smart city research and implementation in each country. First, as mentioned, the literature comprising the Japanese network is dominated by publications from engineering fields with a technology-oriented focus. Additionally, publications in journals from interdisciplinary, social science or humanities fields are overall less prominent than in Sweden. Second, in Japan, large private corporations typically play a leading role in planning and implementing smart cities (Nyberg and Yarime 2017). With the magnitude of this role typically larger than that of other actors, such as municipalities, smart city projects are often shaped around the strengths and priorities of these corporations (Barrett et al. 2021). Consequently, there is less likelihood that publicly oriented issues, such as sustainability, equity, governance and citizen participation, would be promoted as much as technological agendas.

In Sweden, however, though technological discussions also dominate the co-occurrence network, social aspects stand out more prominently. This was detected with a higher representation of keywords, such as “sustainable”, “government”, “citizen”, “life” and “regulation” than in Japan. Two factors can likely explain this difference. First, in Sweden’s sample there is a larger overall representation of publications from social science and humanity fields. Second, in smart cities featuring in the Swedish network, the analysis suggests that local government and other societal actors frequently play a prominent role in project design, implementation and governance. In addition, results indicate that, conceptually, the smart city is more readily associated with sustainability (which implies social dimensions as part of the triple-bottom line) than in Japan, where energy forms a major focus.

Another regional difference observed concerns differing perceptions of vulnerability and hazards in smart cities. Analysis of Sweden’s research network revealed a distinct focus on protecting national and European power grids from anthropogenic hazards such as cyber attacks. Meanwhile, in Japan, which has experienced the Great East Japan Earthquake and tsunami, the concept of vulnerability is interpreted and pursued differently. Here, we found a focus on building resilience towards natural hazards through distributed energy production and redundancy measures in technological systems.

In depicting these diverging approaches to the conception and materialisation of smart cities, this study shed light on the influence of unique social, geographical, cultural and knowledge production trends in Sweden and Japan. As embodied in the concept of “glocal” urbanism (Dameri 2019), our evidence supports the view that smart cities are not only shaped by global technological trends, but equally by local needs, policies, governance norms and historical framings of environmentally oriented urban development (Dameri 2019; Sepasgozar et al. 2019; Varró and Bunders 2020). The implication here is that simultaneously considering local, national and global influences may be crucial to understanding why particular smart cities are conceived and implemented in specific ways. Moreover, this perspective suggests that the societal objectives pinned to technologies (Glasmeier and Nebiolo 2016; Trencher 2019) may be just as important for driving smart city innovation as technological development per se.

Several opportunities for policy, research and practice flow from these findings. The first concerns the over-representation of technologically oriented research and comparatively less focus on the human dimensions of smart city projects. Given the need to make the technological agendas of smart cities more socially relevant, there is clearly scope for supporting a wider integration of citizens and corporate players (e.g. smaller technological entrepreneurs) into smart city planning and implementation. This could be achieved by stipulating attention to social agendas and participatory governance in funding programs, for example, and by explicitly linking smart technology development to societal challenges, as Japan has in its vision of a Society 5.0 (Deguchi 2020; Barrett et al. 2021). There is also room for researchers to take more interest in these areas. Efforts from governments in both countries to support research and projects in social issues beyond energy and environmental preservation would be important given the projected acceleration of significant societal challenges such as the aging population.

Second, and connected to this, we observed a vibrant albeit marginal discussion of Swedish and Japanese cities experimenting with smart technologies in the goal of addressing health and aging issues. Given the increasing global interest in the application of smart technologies to the arena of health and population aging (Rocha et al. 2019a, b; Buttazzoni et al. 2020), there is an important opportunity for Sweden and Japan to share emerging experiences in this field.

Third, results suggest rich opportunities for research and technological collaborations around risk and vulnerability as both countries adapt to the increasing digitalisation of urban infrastructure. This field provides opportunities for Japan to export its increasing experience in increasing the resilience of power grids and urban infrastructure against natural hazards, such as earthquakes, typhoons and floods. This is an especially relevant task given that the latter two are projected to intensify globally due to climate change. Japan, meanwhile, could learn much from the early experiences of Sweden and Europe in protecting grids and urban infrastructure from disruptions of human-origin, such as cyber-attacks.

Fourth, several unique areas identified in the Swedish network offer important opportunities for future smart city development in Japan. For example, Japanese city planners and researchers could learn from Sweden and Europe's historical integration of holistic goals related to sustainability into smart cities. They could also learn from the policy and regulation focused discussions about smart grids and district heating due to the longer experiences in Sweden and Europe with market liberalisation. Finally, research and experimentation with smart district heating in Sweden would also harbour important insights for decarbonisation prospects in Japan. Currently, this infrastructure is largely undeveloped in Japanese cities, especially in the residential sector.

Finally, our study provides several insights for further research. Other studies might include grey literature, such as government reports or trade articles, online articles and newspapers to explore the practices and discourse of a wider variety of stakeholders. Next, although a multi-lingual analysis was beyond the scope of this paper, future investigations might examine literature in multiple languages. It is possible that some topics are underrepresented in our sample due to the focus on English language only. Additionally, searches with different combinations of key words would likely turn up different results. For instance, while this study focused on "smart cities" and "smart grids", future studies might consider alternative or emerging labels, such as "automated", "digital", "intelligent", "resilient", "viable", and so forth. This would be especially important given our finding that the use of differing smart city labels (i.e. "sustainable smart cities" in Sweden and "smart communities" in Japan) can vary according to geographical context. Scholars might also heed attention to how differing conceptions of smart cities have evolved over time, since the appearance of labels like "viable cities" in Sweden and "super smart cities" in Japan suggest that conceptions of digitally enabled cities are constantly evolving. Lastly, in identifying thematic trends in Sweden and Japan, we categorised our sample of literature in accord with author affiliations. Since this does not assure that all publications are focused on either country, future studies could sharpen the geographical focus of sampled literature by omitting studies focused elsewhere.

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