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Abstract

In cities, a majority of the world's GDP and global greenhouse gas emissions are generated. Sustainability has to a great extent, become a priority for the United Nations, climaxing in the new Sustainable Development Goals (SDGs) in 2015, including a goal for sustainable cities. Cities are interesting ecosystems that deal with all types of sustainability by adopting different technologies to transform themselves while making environmental, social, and/or economical changes. With the help of technology, a city has the ability to realize effective business decisions and develop in newer and better ways. In this study, we set out to investigate the influencers of the role of information systems in SSCs by developing an initial theoretical framework based on Technological-Organizational-Environmental (TOE) framework and Functional Affordances and develop this through the analysis of 141 Information Systems (IS) solutions and four interviews. We extend the initial framework with additional attributes resulting from the study and propose a revised framework.

Introduction

In September 2015, the United Nations published 17 Sustainable Development Goals (SDGs), to *"end poverty, protect the planet, and ensure prosperity for all"* (United Nations, 2015). As suggested by the Brundtland Report (1987), the SDGs include environmental, social and economic goals in order to achieve their targets. World leaders are committing themselves and their countries to moving in the right direction, however their efforts are often too little or too slow. Included in the SDGs is Goal 11, which is for Sustainable Cities and Communities (United Nations, 2017). It is important to highlight that by 2050, three quarters of the world's population will live in urban environments (Pearson, 2014), increasing by 2 billion to reach 6 billion (World Bank, 2017). In addition to this, 80% of the world's GDP is generated in cities accounting for more than 70% of global greenhouse gas emissions (World Bank, 2017). With this in mind, cities are a fitting place to focus on when trying to find ways to deal with all types of sustainability (World Bank, 2017). Today, many different thought leaders push for solutions to make cities more sustainable and to develop further in sustainable ways. To achieve this, much research has been conducted: Giddins et al. (2001) explain that developing sustainably is embraced by all, including *"big business, governments, social reformers and environmental activists, all of which put their own interpretation on what sustainable development means"*. It can be suggested that all around the world, cities adopt different technologies as a way to transform themselves towards make environmental, social or economical progress.

There is a certain lack of research around the role that these technologies have in smart sustainable cities (SSC), as well as the forces impacting it. Research by Seidel et al. (2013) offers a way to understand the role IS has for sustainable transformations in a corporate setting. Their paper is solely focused on one organization, however there is an opportunity to implement a similar framework for a more comprehensive overview of the role of IS in a city context, combining it with potential influencers to understand what impacts those roles. Therefore, this paper hopes to make a contribution to the effectiveness of the development of SSCs around the world. While there are many ways to tackle this challenge, as previously suggested, focus here is on IS for sustainability, its role in putting cities a step further to being smart and sustainable, and the influencers involved in this role.

What influences the role of information systems in smart sustainable cities?

Therefore, by using a socio-technical approach this study sets out to answer the main research question by first determining the role information systems play in SSCs. And second, what influences this role of IS. The objectives of this paper are to a) provide a description of the roles information systems have in SSCs, to b) create an initial theoretical framework grounded in existing literature and to c) evaluate the theoretical framework with the help of data collection. To do so, this paper is structured as follows. The first chapter gave a brief overview and introduction of the research topic in focus. The second chapter highlights the methods used, while the third chapter will focus on the information gathered from the conducted classification and interviews. The final, fourth chapter will present a new revised framework, the implications of this study and a brief conclusion.

Literature Review

Smart Cities

Many definitions exist of a 'Smart City' (Albino et al., 2015), and while these differ somewhat, all definitions found use technology-related terms to describe it, and insist on a knowledge-based society. Furthermore, many have broken down the underlying concepts of a Smart City. Most agree on certain dimensions: smart governance, (e-)smart economy, smart mobility, smart environment, smart people, and smart living (Monzon, 2015; Batty et al., 2012; Dash, 2016; Anthopoulos, 2015).

Marsal-Llacuna et al. (2015) explain there has been a shift in recent years for cities moving from sustainable goals to smart city goals. Ahvenniemi et al. (2017) explain that these goals are interconnected, even though not all smart city definitions include sustainability goals. They observe that there is a much stronger focus *"on modern technologies and "smartness""* and social and economic sustainability in smart city frameworks while sustainable city frameworks focus a lot more on environmental sustainability. They recommend the term *""smart sustainable cities" instead of smart cities"* to ensure that sustainability is not forgotten in the development of smart cities (Ahvenniemi et al., 2017). A SSC is defined as a city *"that meets the needs of its present inhabitants [...] without compromising the ability for other people or future generations to meet their needs, and thus, does not exceed local or planetary environmental limitations, and [...] where this is supported by ICT."* (Hilty and Aebischer, 2015).

Sinderen (2011) and Melville (2010) have both been investigating IS in connection to sustainability. Sinderen (2011) advocates how there is an elevated need towards a new form of sustainability *"where ecological, social and psychological dimensions of economic activity are recognized"*, proposing that the role of IS in a technological context is to automate business related operations. Melville (2010), takes a closer look inside the environmental sustainability and the *"critical role that IS can play in shaping beliefs about the environment, in enabling and transforming sustainable processes and practices in organizations, and in improving environmental and economic performance"*. In a paper by Malhotra et al. (2010) Porter and Kramer present an idea about IS for businesses, which can be related to economic sustainability. They define 'Responsive green IS' as IS not directly impacting business' operational activities, and 'Strategic green IS' as IS directly impacting business' own value chain in order to *"benefit society economically and environmentally"* (Malhotra et al., 2010). Loock et al. (2013) take a deeper look into the business operations of a utility company and how the implemented Green IS helped their clients be more aware about their performance in regard to energy consumption and savings.

Theoretical Framework

The theoretical framework of this paper has its starting point in the *Sociotechnical Systems Theory* (STS). It builds on "*[...] Leavitt's (1965) socio-technical model that views four interacting and aligned components—task, structure, people, and technology—as the important dimensions of organizations as work systems"* (Seidel et al. 2013). Leavitt observes the complicated nature of social systems, meaning that *"when technology is changed, the other components often adjust to dampen out the impact of the innovation"* (Keen, 1980).

An investigation from a socio-technical perspective therefore allows change in order to fit the environment of the organization in focus when technology is being implemented (Appelbaum, 1997). Emery and Trist discuss how society is still making use of strategies designed for an environment that is not the one we are currently living in. Trist (1989) explains, the *"technocratic bureaucracies"* cannot cope with the high level of *"interdependence, complexity and uncertainty now to be found in the word environment"* and an unadapted urban design *"cannot absorb environmental turbulence, far less reduce it"*.

For the purpose of this study, cities are considered as organizations, which is suitable as Trist (1981) illustrates the community-based socio-technical endeavors, where socio-technical projects were carried out in a community in regard to economic and social development. Therefore, we draw upon Technological-Organizational-Environmental (TOE) framework which is *"an organization-level theory that explains that three different elements of a firm's context influence adoption decisions"* (Baker, 2012; Dwivedi et al., 2011; Zhu, 2004, Angeles, 2013). The TOE framework allows researchers to study a large variety of innovations as it is applicable to different industries enabling the framework to be used in this research, covering multiple sectors of sustainability.

Functional Affordances

In order to understand the specific role of information systems in sustainability, we are looking at the information system affordances (Seidel et al., 2013; Hedman and Henningsson, 2016). Information system affordances focus on understanding the functional affordances in an organizational environment by *"conceptualiz[ing] and integrat[ing] four key functional affordances that are relevant to implementing environmentally sustainable work practices",* and could be further investigated when considering a city as an organization (Seidel et. al, 2013).

In a nutshell, the main categories of this framework are classified as Sensemaking Affordances and Sustainable Practicing Affordances. In the former, the IS *"afforded possibilities for cognitive activities through which individuals across the entire organization could frame, interpret, and understand the multi-layered and complex issues related to the environmental sustainability transformation"* (Seidel et al., 2013). In Sustainable Practicing Affordances, IS contributes directly to establishing environmentally sustainable work practices and includes *"activities that exert a minimal negative impact on the environment, in terms of the consumption of renewable and non-renewable resources and the associated assimilation of emissions and waste"* (Seidel et al., 2013).

Seidel et al. (2013) suggest that functional affordances can be considered as a suitable framework when conducting research in relation to IS. They explain that it is possible to

separate affordances from different variables such as "*technology properties, user characteristics, and their use of environments"* (Seidel et al., 2013).

Initial Framework

Drawing upon TOE (Dwivedi et al., 2011; Zhu, 2004, Angeles, 2013) and functional affordances (Seidel et. al, 2013), we develop an initial framework. As the model developed by Seidel et al. (2013) is primarily focused on business organizations, the researchers redefined the Sensemaking Affordances and Sustainable Practicing Affordances and adjusted the four functional affordances to fit the purpose of this study, which are visible in Table 1.

Table 1. City Functional Affordances Definitions

City Functional Affordances	Definitions
Reflective Disclosure	In City Reflective Disclosure Affordances, IS contributes to allowing citizens and companies to change their (business) behavior after collecting information. While these may lead to output management, the IS itself does not have any control function over said output management.
Information Democratization	In City Information Democratization Affordances, IS contributes to allowing for the education of citizens or companies to more sustainable ways, either economic, environmental or social.
Output Management	In City Output Management Affordance, IS contributes to allowing citizens and companies to limit their consumption of natural or unnatural resources or to manage the already present output in the environment by incorporating a control (hand control or automatic control) function.
Delocalization	In City Delocalization Affordances, IS contributes to bettering sustainability due to remote capabilities that frees or removes restrictions of location or movement. Only solutions in which the remote capability is a novel use or attribute are included.

In addition to this, the researchers use the TOE framework for inspiration as potential influencers over the role of IS. In a research about sustainability where the word 'Environment' is used to describe the natural world, the term 'Environment' in the TOE framework can lead to misinterpretation. Therefore, this part of the Framework is renamed to 'Context' to avoid any confusion with environmental sustainability. All three areas influencing the Decision-Making in the original framework can be relevant due to the nature of the research question. By adapting the framework, one can hypothesize about how the influencers impact the role of IS in sustainable cities.

The initial framework (Figure 1) is therefore a hypothesis of what influences the role of IS in SSCs. The Technology, Organization and Context factors all influence the Role of IS but their influence on each other is negated in the initial framework as the influence on the role of IS in Sustainable Cities can be seen coming from individual sources and the attributes associated with each influencer also change somewhat.

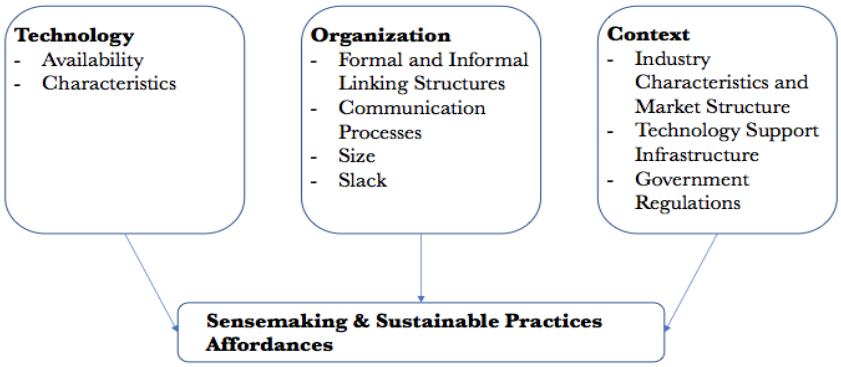

Figure 1: Initial Framework

Methodology

The paper uses both qualitative and quantitative data: Archival and Documentary Research as well as exploratory and evaluative interviews. For the two parts of the study, different kind of data is needed. The data collected for this research uses the State of Green website, a consortium of various Danish public and private organizations (State of Green, 2017), from which 141, from 1352 existing, IS solutions are identified. Additionally, four interviews are conducted as primary sources. The interviews also support the empirical data collection and enrich the findings of the study. Both sources are then analyzed to find the role of IS in SSCs and its influencers.

For the quantitative part of the data collection, the website of State of Green, is used due to their collection of solutions for sustainability and due to their involvement with various stakeholders of SSCs. However, a delimitation is necessary when choosing which solutions could be used for this research. Each solution is evaluated to identify whether they use information systems for sustainable purposes and if they are in urban areas. Conclusively, 141 solutions out of 1352 are found to correspond to the definition set by the researchers.

Additionally, solutions are classified and cross-referenced (Table 2) by their type of Functional Affordances and several other classifiers to get a better overview as well as to discover potential patterns and determine what solution percentage is in each category. The categories include: Name of Owner, Owner Type, Driver Type, Sustainability Type, Place of Sustainability, Sector, and Functional Affordance. These categories rose from literature and archival research, such as Seidel et al. (2013), the State of Green Website, or Elkington (1999). Cells F3 and G3 of the classification can be read as of all the Business-owned solutions, 30.6% are government-driven and 69.4% are business-driven. On the other hand, cells C6 and D6 are different as they review respectively out of all the government-driven solutions, how many are business-owned and out of all the business-driven solutions, how many are business-owned.

Table 2. Cross table of functional affordances and sectors

		Sustainability			Place				Sector										Functional Affordances of IS			
		Environmental	Social	Economic	Home	Combination	Outside	Street	BioEnergy	Climate Adaptation	Energy Efficiency	Environment & Resources	Heating & Cooling	Intelligent Energy	Solar & Other Renewables	Sustainable Transportation	Water	Wind Energy	Reflective Disclosure.	Information Democratization	Output Management	Delocalization
Initiators & Lead Driver	Business owner	84.3%	33.9%	70.2%	24.0%	10.7%	56.2%	9.1%	1.7%	8.3%	60.3%	19.8%	20.7%	48.8%	8.3%	9.1%	22.3%	5.0%	57.0%	10.7%	40.5%	4.1%
	Government Owner	100.0%	43.8%	62.5%	12.5%	0.0%	62.5%	25.0%	0.0%	0.0%	31.3%	12.5%	18.8%	68.8%	18.8%	18.8%	31.3%	0.0%	50.0%	18.8%	56.3%	6.3%
	University Owner	75.0%	75.0%	25.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	75.0%	0.0%	0.0%	50.0%	0.0%	0.0%	25.0%	25.0%	50.0%	0.0%	75.0%	0.0%
	Government Driven	93.0%	54.4%	50.9%	7.0%	10.5%	57.9%	24.6%	0.0%	7.0%	47.4%	17.5%	10.5%	47.4%	8.8%	17.5%	31.6%	0.0%	50.9%	19.3%	45.6%	3.5%
	Business Driven	81.0%	23.8%	79.8%	32.1%	8.3%	58.3%	1.2%	2.4%	7.1%	64.3%	19.0%	26.2%	53.6%	9.5%	4.8%	17.9%	7.1%	59.5%	6.0%	41.7%	4.8%
Sustainability	Environmental	100.0%	32.2%	66.9%	21.5%	10.7%	55.4%	12.4%	0.8%	5.8%	57.9%	19.0%	19.8%	52.9%	15.7%	11.6%	27.3%	3.3%	53.7%	13.2%	45.5%	4.1%
	Social	76.5%	100.0%	37.3%	23.5%	0.0%	52.9%	23.5%	0.0%	13.7%	54.9%	27.5%	9.8%	52.9%	7.8%	19.6%	17.6%	5.9%	51.0%	17.6%	41.2%	5.9%
	Economic	84.4%	19.8%	100.0%	24.0%	13.5%	58.3%	4.2%	1.0%	6.3%	64.6%	13.5%	21.9%	51.0%	11.5%	5.2%	24.0%	4.2%	63.5%	5.2%	39.6%	4.2%
Place	Home	83.9%	38.7%	74.2%	100.0%	0.0%	0.0%	0.0%	0.0%	9.7%	90.3%	16.1%	25.8%	77.4%	9.7%	3.2%	3.2%	3.2%	54.8%	19.4%	54.8%	3.2%
	Combination	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	61.5%	15.4%	30.8%	61.5%	0.0%	7.7%	46.2%	0.0%	84.6%	7.7%	15.4%	15.4%
	Outside	81.7%	32.9%	68.3%	0.0%	0.0%	100.0%	0.0%	2.4%	8.5%	47.6%	19.5%	18.3%	36.6%	9.8%	6.1%	30.5%	6.1%	53.7%	8.5%	41.5%	2.4%
	Street	100.0%	80.0%	26.7%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	40.0%	20.0%	6.7%	66.7%	13.3%	46.7%	6.7%	0.0%	46.7%	13.3%	53.3%	6.7%
Sector	BioEnergy	50.0%	0.0%	50.0%	0.0%	0.0%	100.0%	0.0%	100.0%	50.0%	50.0%	50.0%	50.0%	100.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
	Climate Adaptation	70.0%	70.0%	60.0%	30.0%	0.0%	70.0%	0.0%	10.0%	100.0%	40.0%	40.0%	10.0%	30.0%	20.0%	30.0%	30.0%	10.0%	40.0%	10.0%	70.0%	0.0%
	Energy Efficiency	86.4%	34.6%	76.5%	34.6%	9.9%	48.1%	7.4%	1.2%	4.9%	100.0%	17.3%	23.5%	66.7%	7.4%	7.4%	7.4%	3.7%	53.1%	12.3%	49.4%	3.7%
	Environment & Resources	88.5%	53.8%	50.0%	19.2%	7.7%	61.5%	11.5%	3.8%	15.4%	53.8%	100.0%	30.8%	57.7%	3.8%	23.1%	15.4%	7.7%	53.8%	11.5%	50.0%	7.7%
	Heating & Cooling	85.7%	17.9%	75.0%	28.6%	14.3%	53.6%	3.6%	3.6%	3.6%	67.9%	28.6%	100.0%	50.0%	14.3%	3.6%	3.6%	10.7%	50.0%	10.7%	57.1%	0.0%
	Intelligent Energy	88.9%	37.5%	68.1%	33.3%	11.1%	41.7%	13.9%	2.8%	4.2%	75.0%	20.8%	19.4%	100.0%	6.9%	13.9%	12.5%	2.8%	58.3%	13.9%	45.8%	6.9%
	Solar & Other Renewables	76.9%	30.8%	84.6%	23.1%	0.0%	61.5%	15.4%	7.7%	15.4%	46.2%	7.7%	30.8%	38.5%	100.0%	23.1%	7.7%	7.7%	53.8%	15.4%	53.8%	0.0%
	Sustainable Transportation	100.0%	71.4%	35.7%	7.1%	7.1%	35.7%	50.0%	7.1%	21.4%	42.9%	42.9%	7.1%	71.4%	21.4%	100.0%	7.1%	7.1%	57.1%	21.4%	42.9%	7.1%
	Water	100.0%	27.3%	69.7%	3.0%	18.2%	75.8%	3.0%	0.0%	9.1%	18.2%	12.1%	3.0%	27.3%	3.0%	3.0%	100.0%	0.0%	69.7%	6.1%	27.3%	6.1%
	Wind Energy	66.7%	50.0%	66.7%	16.7%	0.0%	83.3%	0.0%	0.0%	16.7%	50.0%	33.3%	50.0%	33.3%	16.7%	16.7%	0.0%	100.0%	66.7%	16.7%	50.0%	0.0%
Functional Affordances of IS	Reflective Disclosure	82.3%	32.9%	77.2%	21.5%	13.9%	55.7%	8.9%	0.0%	5.1%	54.4%	17.7%	17.7%	53.2%	8.9%	10.1%	29.1%	5.1%	100.0%	3.8%	7.6%	6.3%
	Information Democratization	100.0%	56.3%	31.3%	37.5%	6.3%	43.8%	12.5%	0.0%	6.3%	62.5%	18.8%	18.8%	62.5%	12.5%	18.8%	12.5%	6.3%	18.8%	100.0%	43.8%	0.0%
	Output Management	90.2%	34.4%	62.3%	27.9%	3.3%	55.7%	13.1%	3.3%	11.5%	65.6%	21.3%	26.2%	54.1%	11.5%	9.8%	14.8%	4.9%	9.8%	11.5%	100.0%	0.0%
	Delocalization	83.3%	50.0%	66.7%	16.7%	33.3%	33.3%	16.7%	0.0%	0.0%	50.0%	33.3%	0.0%	83.3%	0.0%	16.7%	33.3%	0.0%	83.3%	0.0%	0.0%	100.0%

Moreover, to answer the second part of the question, the researchers went into the field to speak face to face with professionals who are familiar with the influencers and procedures of SSCs. Therefore, the researchers interviewed four individuals, from both private and public sector, who are executive managers and oversee projects at large. The study does not focus on individual citizens due to the need of a very large sample to be representative of the population, as well as the study being from the point of view of the executive branch of a city. Additionally, citizens themselves do not have the power to implement the IS solutions at hand. The goal of the interviews is to get the interviewees' general view on IS helping cities to become sustainable and to get their opinion about the initial framework of influencers on the role of IS.

Table 3. Overview of interviews conducted.

Interviewee	**Title**	**Organization Type**	**Interview Location**	**Interview Date**	**Interview Duration**
Interviewee A	Senior Vice President Global Marketing	Private Organization	Skanderborg	September 27th, 2017	1:19:08
Interviewee B	Energy Consultant	Public Organization	Frederiksberg	October 5th, 2017	1:31:49
Interviewee C	Chief Consultant	Private / Public Organization	Albertslund	October 5th, 2017	1:22:35
Interviewee D	Head of Municipal Development	Public Organization	Copenhagen	October 12th, 2017	0:52:36

For the Analysis, the classification and the interviews are used as they represented all data collected, therefore giving the most complete overview of the findings. The analysis concerned how those could add to, confirm, or revoke the initial framework. The first part of the analysis focuses on the first question about the role of IS in sustainable cities. By classifying the solutions, the researchers are able to determine what the role of IS was. The second part of the analysis, focuses on certain themes that had come up in the interviews. Different areas of analysis were used to formulate the revised framework, presented in Figure 2 and 3.

Analysis

The analysis is made from the information gathered through the interviews and classification (transcriptions and original classification are available on demand). Both suggest developments for a transition from the initial framework to the final framework. The three influencers of Technology, Organization and Context are found to influence each other as well as the Functional Affordances, new influencers from the Classification are validated such as the Drivers, Sustainability Type and Sustainability Sector while the Place of Sustainability is considered to be an influencee of the Functional Affordances. Additionally, information emerges about the underlying attributes of certain influencers. This study investigates a variety of projects by governments, universities and private businesses, to understand what influences

the role IS plays in creating SSCs. IS has a role in SSCs, and has the potential to alter the way individuals and businesses think and act towards the environment now and in the future. The solutions are first analyzed to answer the first question of this research. Based on the findings from the classification and conducted interviews, the initial framework is thus modified and a revised framework will be created to reflect the new information from the qualitative and quantitative data.

Various solutions were classified in order to find the role of IS in SSCs. As mentioned, 79 fit in Reflective Disclosure Affordances, 16 in Information Democratization Affordances, 61 in Output Management Affordances and 6 in Delocalization and through the classification one can see that while the role of IS in SSCs fits in all four categories of Functional Affordances, the solutions were in majority in Reflective Disclosure Affordances and Output Management Affordances. They are also in Informational Democratization and Delocalization, but to a much smaller extent. Therefore, it can be proposed the main role of IS in SSCs is to allow citizens and companies to change their behavior after collecting information as well as allowing citizens and companies to limit their consumption of natural or natural resources or to manage the already present output in the environment by incorporating a certain control. To a lesser extent, IS also allows for the education of citizens or companies to more sustainable ways, either economic, environmental or social, and to improving sustainability due to remote capabilities that frees or removes restrictions of location or movement (Table 1). In addition, interviewees found the Functional Affordance classification of IS to be pertinent. Both Interviewees B and C thought IS plays a role of Sensemaking and of Sustainable Practices, with Interviewee C also mentioning that much work was currently being done for creating a Delocalization foundation. Interviewee A agreed with the conducted classification and also placed their solutions under Reflective Disclosure Affordances, with some in Output Management Affordances. The Functional Affordances remained untouched as all areas are roles of IS in SSCs, with an accent on Reflective Disclosure and Output Management Affordances.

In a nutshell, the research uncovered that the role IS plays in SSCs is primarily to change behaviour based on collected data - for instance using the information gathered through IS to make more informed decisions about energy or water consumption. In addition, IS is also often a helpful tool for organizations to reduce their consumption of resources or manage already existing outputs by incorporating manual or automatic functions - for instance using IS to optimize energy use through adaptive lighting, which relies on a software system enabling *"adaptivity in the behaviour of the system"* (State of Green, 2017).

Technology, Organization and Context Influence

The findings enabled the relationship between the T, O and C influencers to be clearer and showed that it was also present in a city context. When referring back to the original TOE framework, communication, size, and human resources are some of the main characteristics when understanding the key elements of any organization. The research illustrates that the importance and use IS has in organizations differs greatly. None of the organizations understand or use technology the same way. As pointed out in the original framework, there are different characteristics, which all have a major influence on the organization and its operations. The interviews suggest that the implementation of new technological solutions is often perceived to be an expensive and challenging process for an organization. It was argued that people's existing and nonexistent experience with technology is what often influences the implementation of technological solutions. Moreover, according to the findings the adoption of IS also often comes down to clear communication - *"Communication processes within the*

organizational context can also promote or inhibit innovation" (Baker, 2012). It can be proposed that technology implementation often comes down to availability of resources and/or skills that an organization has at their disposal. The interviews also proved that managers and government officials can steer technological change. This can either assist or prevent incremental change towards a SSCs, proving again that there is a close relationship when it comes to organizational impacts on technology. Thus, according to the TOE framework and information obtained from the interviews, one can clearly see the influence organizational elements have on technology, its use, and adoption for a more smart sustainable city.

When looking at the organizational impact on Context, one must understand that cities are noticing incremental environmental changes pushing them to implement solutions consuming *"less energy and make systematic use and reuse of materials"* or *"developing technologies to restore, protect, and manage natural ecosystems"* (National Research Council, 1995). It is however almost impossible for cities to create their own solutions, encouraging collaboration with private companies and consulting firms. Common industries for sustainability are water, energy and mobility and both public organizations interviewed acknowledged their partnerships with the private sector to create new projects, gain knowledge and test solutions. The interviews discussed how the Living Labs act as showrooms for the public sector to conduct experiment with solutions, which can be implemented in larger contexts (Interviewee C & Interviewee D). Furthermore, the classification, through the differences between drivers and owners, reveals that many governmental projects collaborate with the private sector to utilize technological solutions towards sustainable cities. This can also be described as following: *"While governments play a critical part in the attainment of sustainable development, the extensive capabilities of the private sector—particularly in relation to technology development and technology transfer—also have a key role"* (National Research Council, 1995). In addition to working with private companies, Interview D's municipality often act as mediators between foreign delegations and their own collaboration partners, to present solutions and technologies that have been used in specific settings to wider markets. It can be suggested that cities influence the Context with mean and location of potential future business. It can be argued that organizations impact the Context in which decisions are made and strategies implemented. Even though it is challenging to discuss how a city as an organization influences the Context at large, one can agree that a city is often managed similarly to traditional organizations. Businesses have top management and CEOs, and in cities, government top level officials act as the executive management team - often being the direct decision makers when it comes to adopting new technologies, solutions, strategies, and more (Interviewee D). Additionally, like many conventional organizations, cities must consider the financial, social, and environmental aspects before implementing change, thereby influencing the context they work in.

In one way or another, technology in the 21st century has a great impact on the organizational structure. It can be suggested that as technology plays an ever growing role in modern society, it is helping to lead change across industries. For instance, it can help an organization to experiment with new solutions, to advance their current processes and reach future goals. However, as supported by the interviews, technological advancements can easily bring confusion to companies' daily activities (Interviewee B): He cites an example with the Energy Performance contract set up a few years earlier, saying they had put tablets on each floor but shortly after they were installed, *"everything crash[ed]"*. Yet, technology has the potential to change not only the operational processes, but also organizational culture and ways people work. Baker (2012) states that improved utilization of current technologies and/or the adoption of new technologies can lead to better organizational structure and company culture. However,

this is not always the case. Research suggests that technological implementations do not always help with occurring problems, especially when there is a technical knowledge gap. According to Interviewee C, cities do not know the solutions that are available or what they want: The people they work with do not have *"the competencies too actually know what to buy"* and *"it [could] be difficult as a buyer, as a city, trying to go out and buy these solutions because it is very complex"* (Interviewee C). Thus, the different technological solutions in the market can render the choice difficult for the direct decision-makers, due to opportunities being endless. Therefore, it can be suggested that the complexity of technological solutions and their availability in the marketplace can influence a solution's implementation. Additionally, the technological implications could often vary when it comes to organizations, as they are often dependent on the specific characteristics involved. Thus, one can argue technology certainly impacts the organization. More precisely, technology has the power to challenge and change organizational structure, activities and human behavior, while offering organizations opportunities for growth, and cost effective approaches towards a sustainable future.

Technology does not only influence the internal activities of an organization, but also plays a key role in establishing the external Context. Nowadays, technology helps to create a competitive advantage to stay ahead of competition in the marketplace. Competition on the other hand, has the potential to encourage the adoption of innovations (Baker, 2012): Literature suggests that *"with regard to industry life cycle, it is argued that firms in rapidly growing industries tend to innovate more rapidly"* (Baker, 2012). The collected data predictably exhibits the popularity of sustainable IS projects in sectors such as Intelligent Energy and Energy Efficiency. Decarbonization is one of the most urgent priorities for many countries, and research shows that a large number of sustainability related projects in cities aim to improve urban infrastructure, transportation, food and water. Hence, this proves the world is gradually transitioning from fossil fuels to renewable energy, or encouraging change for energy consumption reduction (Pearson et al, 2014). This process however is extremely long and difficult, and could be even more so without advancements in technological innovations. Technology has also contributed to the creation of the 'Copenhagen map', incorporating large amounts of data and allowing organizations make decisions based on easy-to-find information about city infrastructure, landscape, architecture and more (Interviewee D). Thanks to these projects, organizations can look to other markets and industries to reuse data for further advancements. This research demonstrates that while technological developments are often complex, they are necessary in the changing market, where they often innovate and disrupt. Organizations should not overlook the importance of collaboration and must fully understand the market and industry structure they work in, in order to advance a city's ambitions for a sustainable future while simultaneously pleasing stakeholders.

The conducted research supports that market structure, industry characteristics and government regulations do influence an organization's activities and objectives. Interviewee C explained that currently, there are many differences between the national government and local municipalities when it comes to sustainable initiatives, which is detrimental to change. For instance, the tax system on vehicles could be more favorable for sustainable cars. However, since the sustainability agenda is not as high of a priority for governmental activities, the regulations currently restrict certain organizational objectives (Interviewee C). Hence, organizational developments often rely upon the pertinent regulations, having the power to determine the context in which organizations are allowed to operate. Moreover, the researchers notice that slight competition has the potential to influence organizational goals. Interviewee B pointed out that his municipality has established goals similar to Copenhagen, in response to the 2025 CO2 neutral target, aiming to reach the same goal by 2030. This proves that market

characteristics do influence the behavior of an organization, hence supporting the assumption that Context elements from the TOE framework influence organizations.

The numerous characteristics that determine a market and industry structure are often elements which play an important role when it comes to technology. It can be suggested various elements of the Context influence the development and adoption of technology. The interviews showcased that areas such as energy, mobility, and water are where the market structure towards technological sustainability changes, is most advanced and approachable (Interviewee A & Interviewee D). It can be proposed that current industry characteristics often favor organizations prioritizing these three sectors. As further seen in the classification, a majority of technological advancements connected to sustainability take place in those areas. Moreover, according to the TOE framework, one of the crucial elements in the technology-related innovation process is the technology support infrastructure. Its importance can be seen in the conducted interviews, where interviewees B and D explained how they use Interviewee C's company and Copenhagen Solutions Lab to expand their use and implementation of technology related solutions. They do this by using third party technological infrastructures and expertise when going through the process of implementing new solutions: In these circumstances, cities can act both as initiators and customers. In addition to support infrastructure, the interviews illustrated that the implementation and adoption of technology also relies upon circumstances surrounding markets and industries. According to Interviewee A, it is harder to justify investments towards new technologies for cities in a developing country, due to low salaries and municipalities *"can't justify the investment because manual labour is so cheap"*. Regardless of the extent of water and energy waste problems, if a market is not ready for change or if the government is not aware of the benefits technology brings, change happens slowly and the technology adoption process can be said to be harder in developing-country cities than in developed-country cities (Interviewee A). Copenhagen, for instance, is a great example of an SSC. Despite the government not being as sustainability oriented as previously, organizations still implement the HORIZON 2020 program into their clean energy activities (Interviewee D). The regulatory environment can be said to be a key element in determining how and to what extent solutions are used in order to foster urban change. The regulatory context's influence on technology can also be described through technological policy-making created by governments, as technology policies have three main aims concerning raising productivity and social welfare, meeting social needs and improving the technology generation, diffusion and utilization process (UNIDO, 2015). Solutions from the city of Copenhagen for example, often touch upon these three goals, for example the "Copenhagen Intelligent Traffic Solutions", which *"reduce[...] congestion, emissions and increase[...] safety for both vehicular traffic and bicycles"* (State of Green, 2017). The researchers can confidently affirm that different characteristics of Context do influence Technology.

Drivers, Sustainability Type and Sustainability Sector

The research shows that the categories from the classification could also be influencers. The Drivers, Sustainability Type and Sectors are considered as influencers, each having attributes like the Technology, Organization and Context, which are supported by the interview findings (Interviewee A, Interviewee B & Interviewee C). The Drivers' attributes can be composed of the different leaders and stakeholders of the project. Out of 84 business-driven solutions for example, 50 (59.5%) are Reflective Disclosure Affordances, 5 (6%) are Information Democratization Affordances, 35 (41.7%) are Output Management Affordances and 4 (4.8%) are Delocalization Affordances (Table 2), thereby showing that Business drivers have a strong tendency to belong in Reflective Disclosure Affordances. The interviews supported the

findings from the classification. For instance, the private companies had a different use of IS than the public entities interviewed (Interviewee A & Interviewee B). Similarly, it can be suggested that the Sustainability Type and Sector also influence the role of IS with the same kind of relationship emerging in the classification and interviews showing a causal relationship. The authors propose that sectors also have an influence on what type of affordance the role of IS corresponds to, with all sectors being in majority Reflective Disclosure or Output Management Affordances.

Place of Sustainability

While the previous paragraph adds many sustainable factors as influencers, the Place of Sustainability is actually proposed here as an influencee. It is not by determining the Place of Sustainability that one will see what kind of role IS will play, but rather the opposite. The examples can be public Wi-Fi, or IoT solutions which clearly show that the role of IS influences the Place of Sustainability (Interviewee B & Interviewee C)

Technology Attributes

Both availability and characteristics are considered here as influencers. The availability, while not mentioned often, is crucial due to the fact that if a technology is not available, a project will either not continue or ends up using alternative solutions. Additionally, the user-friendliness of technology is key - it is important that the user can make the technology work (Interviewee B). These characteristics influence the role of IS in how the technology is setup to function, and how the existing IS base enables stakeholders to develop new solutions that can work with it. However, at the same time, it blocks development in case of lock-in, or influences the nature of the experiment so that it is possible going from a pilot to solution rollout (Interviewee C).

Organization Attributes

The interviews indicate that the 'formal and informal linking structures' of organizations have an impact on the solutions implemented and therefore on IS's role. Working in silos, extensive inter-team or inter-department work will influence solutions, like Open Data Platforms, and impact IS's role. City silos' employees can have a hard time understanding the new solutions are *"actually creating added value"* and to avoid thinking the ones working for the smart city initiatives are not after their jobs (Interviewee C). 'Communication Processes' also have an impact through communication activities set up between stakeholders. City size can influences the role of IS: due to its size and urbanization, Interviewee B's municipality can install solutions covering the entire municipality. Similarly, small cities may not need complex and detailed solutions that bigger cities require (Interviewee A). A city's slack resources determine not only the investments in sustainable solutions, but also what kind of solutions they invest in: some are more expensive than others, like large infrastructure or network changes (Interviewee A). Additionally, the topic of technology use and comprehension was recurring. In certain organizations, it is important to see whether existing IS systems are used, to determine the role of IS in sustainable settings (Interviewee B). If a solution is created, and should influence behavior by collecting information, individuals need to actually use the solution for it to act with its intended role. It is proposed here, that while the authors are looking at creating an organizational level model and not an individual level one, "Technology Use" be incorporated under the Organization Influencer to add the use of technology of individuals within organizations.

Context Attributes

The Industry Characteristics and Market Structure here refer to the competitive nature of the city, as well as the structure of its surrounding cities. Solutions are often cross-borders pushing cities to work together. Additionally, the nature and competitiveness of the city might push implementation of IS, which in turn benefits the economy and people (Interviewee A). While creating holistic solutions, cities take an ensemble view of the problem, allowing solutions to have a different role than when trying to solve one problem in one municipality (Interviewee C). Industry characteristics and market structure relate to the nature of the public and private sector partnerships that are put into place between the municipality, its subsidiaries, and the private sector. While some municipalities do not have many partners, others rely on many of them to develop innovative solutions, like Interviewee D's public organization, partnering with many, *"from small 2 person enterprises who make tomatoes on top of roofs to TDC, Cisco, IBM"*. The Technology Support Infrastructure also guides what cities can build on: solutions, for example needing good quality data, will not be supported if a base infrastructure is not available and therefore changes to implement IS output management solutions, take time (Interviewee C). The levels of government entities also emerged as a recurring theme from the interviews. Due to regulations, when law is enacted, municipalities must abide by it, meaning they are influenced for the role IS is going to take for sustainability (Interviewee B). For municipalities, these regulations might come from an interstate, state or regional level (Interviewee B & Interviewee C). Similarly, also the employees of the municipality must abide by its strategy, and push projects that are within the political agenda's scope (Interviewee D). Therefore, while government regulations have an influence on the role of IS in SSCs, the political climate does too. Accordingly, not only does Government Regulation influence the role of IS in SSCs, but so does Political Climate.

Discussion

The research based on 141 solutions and four interviews allowed the authors to reevaluate the initial framework and alter it by adding potential influencers, which were identified through data collection. The research validated that similarly to the original TOE framework (Dwivedi et al. 2011). The three key attributes do influence each other, and not just the adoption decision of technology or in this case the role of IS, and most of the attributes under the T, O and E umbrella remain the same. Thus, looking at the T, O and C's relationship on each other can be considered important when determining the influencers that impact the role IS plays in sustainable city development. So, instead of Technology, Organization and Context just defining whether a solution is Sensemaking Affordance or Sustainable Practicing Affordance, a deeper analysis of the theory allows one to identify important characteristics which should be considered essential by the organization when deciding how IS can be used in the development of SSCs. Unlike the TOE framework which is used most widely in corporate settings (Dwivedi et al. 2011), for SSCs, additional factors such as the Political Climate and Technology Use are added as attributes influencing the role of IS under the main influencers' umbrella. Additionally, new influencers (Drivers, Sustainability Type and Sustainability Sector) that were discovered through the classification are added as influencers that are not present in the TOE framework due to its differing focus (Dwivedi et al. 2011).

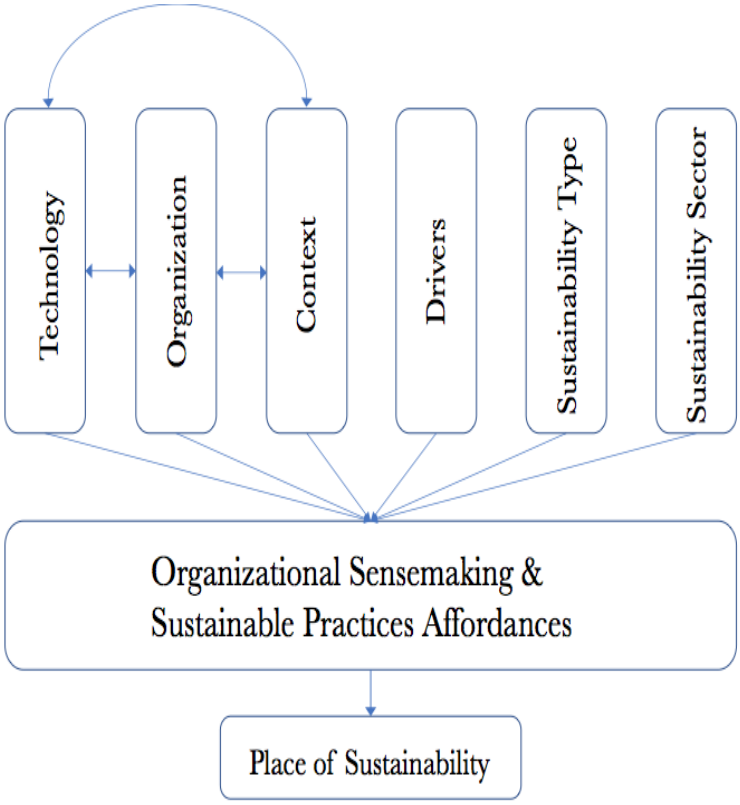

Figure 2: Revised Framework

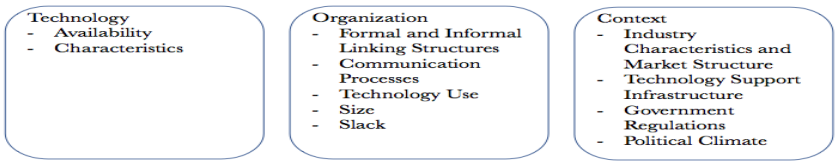

Figure 3: Attributes from the Revised Framework

Implications for Research

As part of the implications for research, this study adds to the existing literature about IS and SSCs. The study contributes new knowledge to an area which had previously not been explored to its fullest and the revised framework is to help to understand what exactly influences the role of IS in SSCs. The research revealed new attributes and influencers that were added to the initial hypothesis, in addition to characteristics of the role of IS that were made known in the revised framework. The main role of IS in SSCs is identified: to collect information to change behavior, and to alter the way and amount in which resources are used. This means there is a difference between the role of IS in corporations and the role of IS in cities, implying that different organizational types will use IS differently. This study also shows that the TOE framework can be used as an inspiration for other intents than decision-making. For example, it was adapted for this research to study influencers of the role of IS. In addition, the framework was used to look at organizations as cities and not corporations, thus widening the arena in which the TOE framework can be implemented in.

Implications for Practice

Concerning implications for practice, this study has an impact for professionals working both in the development of IS solutions for cities, as well as working for cities aiming at being SSCs. In both instances, they would be able to know what influences a city to use IS for a certain purpose or another. Private organizations can also gain insights into how cities go about implementing IS solutions in their quest to become SSCs. This can lead to changes in corporate organization and management. Additionally, public organizations will know what role IS can play in their community, and what influencers need to be considered when implementing technological changes. Furthermore, both types of organizations can focus their resources towards more favorable types of technology, and further down the line to reduce barriers to adoption and acceptance, as the influencers of the role of IS and of technology adoption decision-making (using the original TOE framework) overlap extensively.

Conclusion

This socio-technical study set out to explore the role of IS in SSCs and the influencers of that role through using the classification and interviews. While this study focuses on four key stakeholders, it considers the fact that a better overview could be given through interviews of other segments such as more cities and type of organization. It is acknowledged that a larger sample would optimize the validation of the results.

Throughout the study, a pattern emerged with most solutions fitting the Reflective Disclosure and Output Management categories with only few IS solutions falling under Information Democratization and Delocalization. Causal relationships also became visible from the different solution classifiers. The TOE was found to be a strong theoretical baseline to hypothesize an answer to the research question and the analysis revealed new influencers that were added to the initial framework. Research shows that many stakeholders in the context have an influence that can only be rivaled by organizational structure. Additionally, IS' role, which may seem simple, is part of a very complex phenomenon. Technology Use also turns out to be more chaotic than expected, thus the roadmap to efficient SSC still needs to be drawn. The revised framework is created as an indication of what entities, stakeholders, technologies and sustainable factors influence IS' role for sustainability in cities. Moreover, knowing all that, the implications from the revised framework are hoped to contribute to how a city can execute their sustainable ambitions using technology. The contribution of this study therefore lies in the new knowledge brought to light. Moreover, the revised framework has both implications on research, as well as implications for practice, which contributes to the researchers' goal to contribute in a practical way to the development of SSCs. This study opens up new areas for further research, in order to deepen this new knowledge.

While this study contributes in its own way to SDG 11, much research still needs to be done. First, one could study the link between the Functional Affordances with the traditional role of IS. Furthermore, each attribute of the influencers (in particular Drivers, Sustainability Type and Sustainability Sector) can be further explored. Furthermore, certain personal aspects, such as behavior of individuals concerning change, might influence the use and role of IS in SSCs: a study combining the use of IS and behavioral analysis would be an interesting extension of this study, as well as the real reasons behind cities 'going green' or sustainable. Similarly, a study could explore the different aspects of public and private partnerships in implementing IS for sustainability. Finally, a future study could explore which role(s) of IS are most efficient to create long lasting environment, social and/or economic sustainability.

The authors stay committed to using IS for sustainability in cities and hope to be part of more research and progress in the future. It has never been so important to keep researching how to best use man-made technology to create sustainable solutions in cities. This can be done by uniting researchers from different fields, passionate about sustainability, regardless of changing political and economic landscapes. This study pushes for additional and continuous research for progress in the field, and hopes to contribute to the facilitation of these developments, for further sustainability in cities through the mean of IS.

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