THE RISE OF SMART CITIES – RESULT OF GLOBAL PROBLEMS OR TECHNOLOGY CHALLENGE?

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Abstract. Urban areas are confronted with the problem of high concentration of people with implications for the sustainability, quality of life, and competitiveness of the region. A United Nations (UN) study points out that, for the first time in history, more than half of the population on the planet (54.6 percent or 3.6 billion people) lives in cities. As a consequence of globalization, cities have to solve more problems, public funds need to be better targeted and natural resources need to be explored consciously and responsibly. Digital revolution brought possibility to use technology as a driver to solve old problems by new ways. Moreover, it also brought new options how to enhance sustainable development. Smart City initiatives can be viewed as an innovation as it align new technologies with new processes, new participatory policy, and new management methods. In sum, Smart City represents changes in governance and daily life. In our article we conceptualize Smart City as socio-technical system with focus on the social part. We use traditional socio-technical model, proposed by Leavitt in 1965. We also consider approaches to evaluation of the success of Smart Cities initiatives with possible metrics. As the result we propose evaluation framework for the evaluation of success of Smart City initiatives.

Keywords: smart city, technology, socio-technical system, evaluation

JEL Classification: H70, M15, O32, O33

1. Introduction

The term Smart City is very popular in these days, so that it is almost buzz word. The phrase has been adopted since 2005 by a number of technology companies (Townsend, 2013) for the application of technological innovations to integrate the operation of urban infrastructure and services. Technology can serve as driver to solve old problems by new ways, and also as an innovation that brings new options how to enhance sustainable development (Caragliu et al., 2011; Mulligan & Olsson, 2013).

Smart City concept (Neirotti et al., 2014; Albino et al., 2015) is not new if we think in the dimension of alignment between technology and city governance. Different other concepts have appeared in the past. First attempts to digitize the city date back to the beginning of the millennium with different concepts: Wired City, Digital City, U-City, Information City, Efficient City, Intelligent City or Cyber City. All of those concepts are based on the same assumption that technologies can help cities to be a good place to live.

We can say that cities search for smart solutions that meet three criteria – possibility, desirability, and viability. From technological point of view the solution must be possible. Possibility depends on technological progress as the external factor. However, what is possible depends also on some internal factors – awareness (if we do not know about some solution we cannot use it) and technical infrastructure. Second criterion comprises needs of citizens, business units and city government. Only such technology innovations will be adopted that are desirable. Third criterion focuses on costs and benefits. Even many solutions would be possible and desirable, if there is poor economic viability at the same time, they cannot be realized.

2. Methods

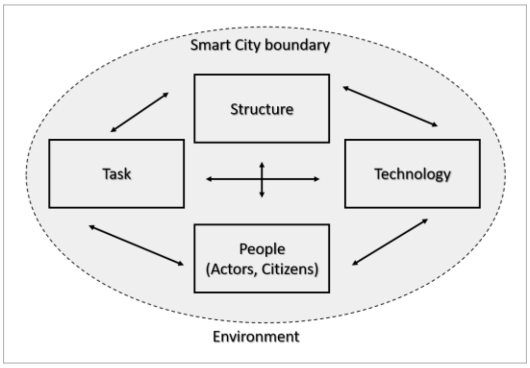
Evaluation of the success of smart city initiatives is necessary for many reasons - in the preparation phase shall be defined expected benefits, after realization of project have to be used metrics to compare reality with expectation, outputs of the project can be compared with similar ones, and even successful projects can be used as examples of good practice (Lee et al., 2014). Today can be found different evaluation frameworks as European Smart Cities Model (Giffinger et al., 2007), Innovation™ Cities Index (2006), Smart City Performance (Lombardi, P., et al., 2012), CITYkeys assessment methodology (2016), etc. All mentioned frameworks have one thing in common, derivation of the frameworks were experience based. Only minimum research articles focused on the evaluation of impacts of smart city initiatives. In this paper, we use Leavitt's model (Leavitt, 1965) to conceptualize smart city as socio-technical system with its elements and relations. Then we try to assign indicators of CITYkeys methodology into Leavitt's model in an attempt to determine whether they are compatible.

3. Conceptualization of Smart City as socio-technical system

H. J. Leavitt (1965) defined organization as "rich, volatile, complicated but understandable system of tasks, structures, tools (technology), and people in states of continuous change". The concept of people covers all humans in the organization who contribute to the realization of task. Task is the purpose of organization, why the organization exists (e.g. produce goods, provide a service, teach students, serve public). Structure comprises everything what defines the organization - formal and informal structures, processes, ways of communication, and so on. The last concept is technology – all tools, machinery, information technology, mobile technology, etc. Leavitt's model explains that the change in one part of system influences or even may have a negative impact on other parameters.

Municipal government can be also taken as organization in this point of view. We can find all components present plus some more. Most important added component is citizen. People component in Leavitt's model covered only employees while customers were not supposed to push changes or otherwise influence the system. Whereas citizens in smart cities can actively participate on structure changes and even push changes in tasks and technology. New component of the environment correspond to all forces outside city borders influencing system stability. That can be legislation changes, technology development, security and privacy threats, political situation, etc. The city is not only a passive recipient of stimuli from the neighborhood, but it can also influence the environment, especially by its example of good practice. The whole model is depicted in figure 1.

Figure 1: Adaptation of Leavitt's model for Smart City



Source: own adaptation of Leavitt's model (Leavitt, 1965)

3.1 Technology

The development of information and communication technologies is so fast, that enumeration of available technologies would be obsolete even at the time of publication and also too expansive (Paroutis et al., 2014). Instead we divide them into four broad categories: (1) Network infrastructure, (2) Sensor devices, (3) Communication interfaces, and (4) Control centers. Described technology classification for Smart Cities is temporal, we expect that in future will appear new categories with emphasis on quality of the solution (Komarkova et al., 2007; Sedlak et al., 2015) as the development will continue.

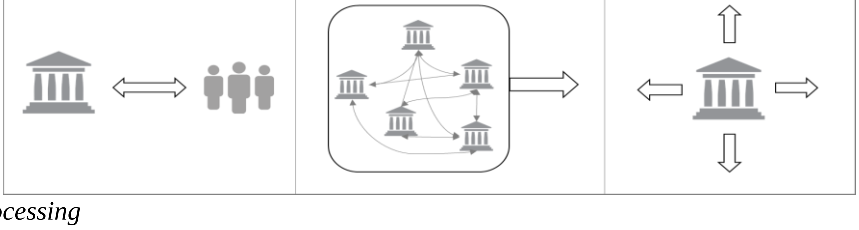
3.2 Task

This part of model address the problem of scope, functions that city performs (Batty et al., 2012). Main function of traditional city is to be safe, livable place that offer its citizens services provided by city government. Essential services cover: city administration, management of utilities, economic development, public safety, management of public buildings, city transport, health services, education, and environment protection.

3.3 Structure

Structure in Leavitt's model represents hierarchy, formal structure, communication channels, and informal structure. Traditional structure of municipal governance expects that citizens engage in public affairs only at election time and then elected representatives take care of the city with minimal interference of citizens. When using Leavitt's model to describe Smart City we need to broaden understanding of structure. Figure 2 shows three most important changes in structure: participatory government, whole-of-government, and open government.

Figure 2: Changes in structure invoked by technology changes (participatory government, whole-of-government, and open government)



Source: own processing

Participatory government means that municipal governments can use information technologies to engage citizens into decision-making. Crowdsourcing can be used for identification of problems, prioritization and finding solutions. Online forums and voting systems give citizens possibility to comment on current events and vote for some alternative. The term whole-of-government expect government departments and agencies to work together as a team for the desired outcome. Smarter government means communication, collaboration, and coordination across departments to be more effective and to be more citizen-centric (Simonova and Novak 2015). Government agencies collect large amount of data that serve as the source for decision-making. But some of those data can be used as open data, which anyone can access, use or share. By opening and sharing of information, Smart Cities can become more transparent.

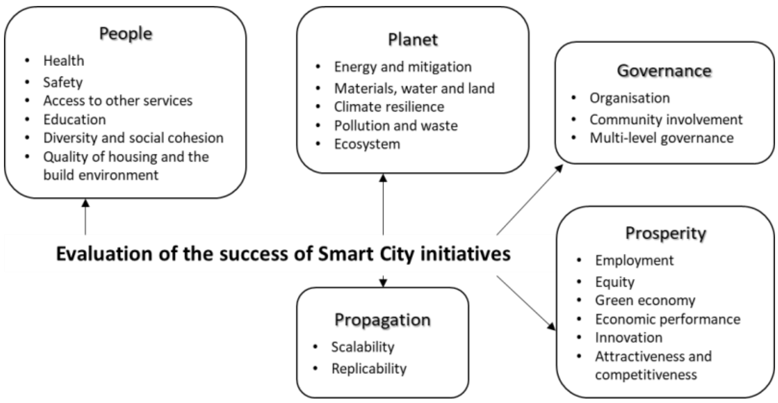
3.4 People

In Leavitt's model are people considered as employees that will be affected by the change in technology, that's why they have to be prepared for this change in order to get expected benefits. In this paper we broaden this perspective to cover users of services (citizens, business), administrators and leaders.

4. Evaluation of the success of Smart City initiatives

For the evaluation of impacts of smart city initiatives, cities can use some published frameworks or they can make their own methodology. The CITYkeys assessment methodology will be used further in this text because it is up-to-date, and it has been created to evaluate European cities thus fits into a cultural context.

Figure 3: Themes and subthemes of CITYkeys assessment method for smart city initiatives



Source: adapted from CITYkeys assessment methodology (2016)

CITYkeys is common integrated performance measurement framework (see figure 3) created to enable cities or other stakeholders in projects to learn from each other, create trust in solutions, and monitor progress. CITYkeys contains indicators for smart city projects, indicators on city level and relations between those two. We will focus on the project level where the majority of indicators have been selected from existing indicator frameworks only

21 new indicators were added specific for smart city projects. Success of project is evaluated according to five themes: people, planet, prosperity, governance, and propagation. People are in the centre of attention that is why city needs to offer quality living for its inhabitants. Second theme is planet, which includes all topics related to sustainability issues. Prosperity means economic viability through economic performance measures, equity, green economy, innovations, etc. Special theme governance is devoted to project management issues, so it is about how the project is being implemented. The last theme propagation is there to show the potential of the project for dissemination to other locations and contexts.

5. Evaluation framework based on Leavitt's model

In this chapter we discuss CITYkeys indicators in relation to particular components of Leavitt's model. The aim of this comparison is to determine whether the methodology takes into account all components – structure, people, technology and task. In figure 4 are depicted CITYkeys indicators assigned to Leavitt's model components with majority of indicators assigned to task component.

First question that needs to be answered is the reason why cities strive to make changes in the way how they do things (offer services). Why do they invest in smart solutions? Is it just because it is possible, meaning that the driver is technology, or is it because cities need to solve some problem so the driver is task? We believe that the second is true. When thinking about some smart city initiative, at the beginning we need to define expected benefits. For the measuring of benefits we can use indicators listed in task component. Some initiatives would focus only on one theme as transportation, security, health, etc., whereas other can be more comprehensive. For example installation of intelligent lampposts can have positive impact on different domains – saving of energy, safety, access to other services (wifi), etc. Offering of indicators for task component is quite exhaustive as the range of services provided is really high. We divided them into three parts – citizen centric, ecocentric, and prosperity centric. Although most of them will be topical even after some time, we can expect changes in services and even broadening of indicators in future.

Selection of task indicators is only initial activity in impact analysis of the change. Assuming city to be a system, we have to expect that change in one component will affect other components, due to their connectedness. At first we will focus on the impact on the structure. As we mentioned in chapter 1.3, traditional structure with citizens that can express their opinion only at election time on one side and municipal government being the authority is slowly changing. At least three new concepts appeared recently – participatory government, whole-of-government, and open government. CITYkeys indicators that would fall under this component cover all three concepts. However, we can see that the greatest attention gets participatory government while integration of public administration (whole-of-government) has only one indicator. We believe that this is an important concept that allows citizens easier access to public services, so the number of indicators should be higher. Possible measures in this area can be - coordination of smart initiatives, sharing of information, security of shared information, clear division of responsibility, online services integration, etc.

If we think about the impact on people, we can do it in two ways. First, what the solution brings to people, what will be the benefits. On the other hand we must ask what that solution will require from them and if they accept it. Indicator of social compatibility forms a precondition for possible acceptance of solution while people reached measure real values of the acceptance. Further there are indicators measuring advantages for end-users and professionals, and ease of use for both. Overall, indicators can be said to be sufficient and we do not expect them to expand.

Figure 4: CITYkeys indicators assigned to Leavitt's model components

STRUCTURE
- Increase in online government services
- Quality of open data
- Bottom-up or top-down initiative
- Local community involvement in planning phase
- Local community involvement in implementation phase
- Participatory governance
- Change in public procurement
- Smart city policy

TECHNOLOGY
- Technical compatibility
- Trialability
- Improved interoperability

PEOPLE
- Social compatibility
- People reached
- Ease of use for end-users
- Advantages for end-users
- Ease of use for professional stakeholders
- Advantages for stakeholders

ENVIRONMENT
- Solution(s) to development issues
- Market demand
- Smart city project visitors
- Visibility of Results
- Diffusion to other locations
- Diffusion to other actors
- Changing professional norms
- Changing societal norms
- Change in rules and regulations
- New forms of financing

Project management
- Leadership
- Balanced project team
- Involvement of the city administration
- Clear division of responsibility
- Continued monitoring and reporting
- Market orientation
- Professional stakeholder involvement
- Municipal involvement - Financial support

TASK

Improved access to basic health care services	Reduction in annual final energy consumption	Increased use of local workforce
Encouraging a healthy lifestyle	Reduction in lifcycle energy use	Local job creation
	Reduction of embodied energy of products and services used in the project	
Waiting time for helth care		Fuel poverty
Reduction of traffic accidents	Increase in local renewable energy production	Costs of housing
Reduction in crime rate	Carbon dioxide emission reduction	Certified companies involved in the project
Improved cybersecurity	Reduction in lifecycle CO2 emissions	Green public procurement
Improved data privacy	Maximum Hourly Deficit	CO2 reduction cost efficiency
Access to public transport	Local freight transport fuel mix	Financial benefit for the enduser
Quality of public transport	Increased efficiency of resources consumption	Net Present Value (NPV)
Improved access to vehicle sharing solutions	Share of recycled input materials	Internal rate of return (IRR)
Extending the bike route network	Share of renewable materials	Payback Period
Access to public amenities	Share of materials recyclable	Total cost vs. subsidies
Access to commercial amenities	Life time extension	Involvement of extraordinary professionals
Improved flexibility in delivery services	Reduction in water consumption	Stimulating an innovative environment
Improved access to educational resources	Increase in water re-used	New startups
Increased environmental awareness	Self-sufficiency - Water	Decreased travel time
Improved digital literacy	Increase in compactness	
Diversity of housing	Self-sufficiency - Food	
Connection to the existing cultural heritage	Climate resilience measures	
Increased use of groundfloors	Decreased emissions of Nitrogen oxides (NOx)	
Increased access to urban public outdoor recreation space	Decreased emissions of Particulate matter (PM2,5)	
Increased access to green space	Reduced exposure to noise pollution	
Increased consciousness of citizenship	Reduction in the amount of solid waste collected	
Increased participation of vulnerable groups	Increase in green and blue space	
Design for a sense of place	Increased ecosystem quality and biodiversity	

Source: own processing

Changes in task necessarily invoke changes in technology. Although smart city innovations are highly dependent on technology, indicators for technology component in CITYkeys methodology are only three. Two of them measure suitability of technical innovation (compatibility and trialability) and only one measure real impact of the solution. According to Rogers (2010) we propose complexity as another suitability measure. The reason is that complex solutions pose more problems in the implementation phase and even during maintenance so this is negatively related to success of initiative. What else we are missing in this component are indicators focused on the quality of implemented solution. Only improved interoperability among systems is present. Software quality metrics (ISO/IEC 25010, 2011; Grady and Caswell, 1987; Walters & McCall, 1979) offer many indicators that can be used. We consider these indicators to be essential and suitable for measuring of success of smart city initiatives: (1) functionality, (2) performance, (3) reliability, and (4) security.

Last component of adapted Levitt's model for smart cities is the environment. We added this component because the initiatives are influenced by examples of good practice and even by forces from central government. On the other hand successful initiatives can be replicated and spread across the globe. Globalization is the driving force for the diffusion of innovations. We divided environment indicators into three parts. First two indicators verify that the innovation is needed, this is the precondition for diffusion of innovation. Following four indicators observe popularity of particular initiative. Other indicators focus on the impact of the initiative – if it made some change.

During the evaluation of CITYkeys methodology we discovered some indicators that did not fit into any component of Leavitt's model. In fact, they were indicators that did not evaluate the impact of the initiative but its course. According to De Witt (1988) we need to differ between success of the whole project and success of project management. „A project can be a success despite poor project management performance and vice versa" (De Witt, 1988). Even though project management criteria are temporal, we accept them to be important during the realization of project.

6. Conclusion

Smart city initiatives bring change into the governance and even everyday life of the city. Most projects are focused on the integration of technological innovations. As the city is complex system with many related components we have to count on that change in one component (technology) would change also other components. In this paper we tried to find indicators for measuring the impact of the change. We used adapted Leavitt's model to define all components and CITYkeys methodology containing indicators for measuring success of smart city initiatives. By combination of those two instruments we proposed addition of new indicators where it was necessary.

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