# THREE MAJOR CITIES OF BADEN-WÜRTTEMBERG - ARE THEY REALLY SMART CITIES?

## Thomas Laue and Birgit Schenk[1]

*Abstract*

*In this paper we discuss the term Smart City and its components, to design a framework to compare three major municipalities of Baden-Württemberg who declared themselves Smart Cities. The theoretical framework is based on scientific definitions for the different terms related to Smart Cities. To compare the cities we gathered open and public data to guarantee transparency of the evaluation. Hence this is only possible when cities are "smart" so that this method is an indicator itself of a Smart City. We focused on three major cities of Baden-Württemberg who already advertise for being a smart city in comparing different studies.*

*Keywords: Smart City, Smart Service, Smart Data, Baden-Württemberg*

## 1. Introduction

The term „Smart City" and all its linked buzzwords e.g. Smart Services, Smart Data  etc. are for many people in public service a vague term and holds a lot of issues. The questions result from the term itself and the necessity to objectively verify, if their own city is already a „Smart City". So the paper provides a framework based on the aspects of the term Smart City which allows to benchmark and assess municipalities.

First of all, we need to clarify the term "Smart City". The development of the «Internet of Things» [1], the intelligent connection of real and virtual objects, led to the foundation of the digital transformation in business and the economy which will leave neither government nor public administration at all levels unaffected. Focusing digitalizing in town and country the term  «Smart City» has been established.

Smart Cities are towns which are seeking a way to manage the growing complexity in the use and implementation of intelligent networking information- and communication technology to connect its sub-systems and overcome existing barriers to create a single organic whole. [2] Chourabi et al. [3] describe this as follows: «The new intelligence of cities, […] resides in the increasingly effective combination of digital telecommunication networks (the nerves), ubiquitously embedded intelligence (the brains), sensors and tags (the sensory organs), and software (the knowledge and cognitive competence)».

As well as managing complexity with the concept of Smart Cities it is also implemented to manage the future challenges such as urbanization, use of resources, a rising need for security, changing demographics, etc. which will hit us in the coming years because the smart city concept offers various innovative intelligent solutions and brings value to society. The added value comes with the opportunity to offer so called Smart Services tailored to the customer's needs. E.g. in respect of

[1] University of Public Administration and Finance Ludwigsburg, Germany, schenk@hs-ludwigsburg.de

public administration this implies the possibility to offer smart services for citizens to improve their daily life.

Analyzing two European and three national studies of "Smart Cities" allows us to evaluate, if some of Baden-Württembergs cities are already smart cities according to relevant standards. Therefore the theoretical framework is used to link empirical data of these selected studies which all focus on the same or similar aspects when it comes to the topic of a smart city. We benchmarked only cities whose data are publicly available or already used in public studies. Therefore our methodology in itself guarantees that we focus on smart cities and is an indicator of a smart city itself, because transparency is one of the factors of being smart. Three major cities of Baden-Württemberg offer the needed data and are part of the included studies, so we focused on them: Karlsruhe, Stuttgart, Mannheim.

## 2. National and European Studies of Smart Cities

Our framework is based on the following studies, which focus on Smart Cities Acitivies and Developments: European Smart Cities of Griffinger et al. [4], Digital Economy and Society Index (DESI) [5], "Morgenstadt-Initiative" of the Fraunhofer Institute of Industrial Engineering IAO [6], the Deloitte Index of Digital Competitiveness of German Municipalities [12], and the Ranking of Cities of Cultures [13].

**European Smart Cities**

There are many areas in which a town can invest in order to be able to offer smart services to become a smart city. Griffinger et al. [4, p.11] identified six key areas: Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment, Smart Living. To describe a smart city and its six characteristic areas Griffinger et al. [4, p. 12] developed a transparent and hierarchical structure, in which each level is described by the results of the level below. A smart city consists of six characteristic areas, which are described by 31 factors. The 31 factors are defined by 74 indicators, which are used for operationalizing and aggregating the relevant factors. To give an example how it works: 'Smart people' as characteristic is defined through the 7 factors (level of qualification, affinity to lifelong learning, social and ethnic plurality, flexibility, creativity, cosmopolitanism/open-mindedness, participation in public life); for instance, the factor 'affinity to lifelong learning' is then operationalized through the indicators 'Book loans per resident', 'Participation in life-long-learning in %' and 'Participation in language courses'. [7, p. 14]

The ranking approach of 2007 [p.11] focused on medium sized cities in Europe and the following objectives:

*"(1) transparent ranking of a selected group of cities*

*(2) elaboration and illustration of specific characteristics and profiles of every city*

*(3) the encouraging of benchmarking between selected cities*

*(4) identification of strengths and weaknesses for strategic discussion and policy advice."*

Due to accessibility and quality of data 70 European cities were ranked starting in 2007 [4, p. 14, see also 8].

In collaboration with various private and public partners the original Smart City Model was continuously improved considering definitions and data base. At the moment the 4th version is available. Version 1 focused cities of up to 500.000 inhabitants. Version 4 is enlarged and can be used to analyze cities of 300.000 to 1.000.000 inhabitants. Therefore version 4 consists of 27 factors and 90 indicators.

**Digital Economy and Society Index (DESI) of the EU**[5]

This index focusses on the digital economy and society. It is a composite index that summarizes relevant indicators on Europe's digital performance and tracks the evolution of EU member states and therefore its cities in digital competitiveness. It focusses on five dimensions: connectivity, digital skills, use of internet, integration of digital technology, and digital public services. The five dimensions are described by sub-dimensions containing indicators. E.g. Digital Skills are based on two sub-dimensions (see fig. 1): (a) basic skills and usage and (b) advanced skills and development. [9]

| *(a) basic skills and usage* | Internet users | People who use the internet at least once a week | All people aged 16-74 |
|---|---|---|---|
| | at least basic digital skills | Skills such as using a mailbox, editing tools etc. | All people aged 16-74 |
| *(b) advanced skills and development* | ICT Specialists | Including jobs like ICT service managers, ICT professionals, etc. | Employed people |
| | STEM graduates | People with a degree in science, technology, maths or engineering-related subjects | All people aged 20-29 |

**Figure 1: Example of the DESI Indicator List**

The aggregation of indicators into sub-dimensions, sub-dimensions into dimensions and the dimensions into the overall index uses simple weighted arithmetic averages following the structure of the index e.g. [10, p.20]:

$$(City) = Connectiv(City) * 0.25 + Human\_capital(City) * 0.25 + Use\_of\_Internet(City) * 0.15 + Integration\_of\_Digital\_Technology(City) * 0.2 + Digital\_Public\_Services(City) * 0.15$$

The DESI was developed to have a sound basis for strategy development considering the relevant indicators on Europe's current digital policy mix. The index allows the following main types of analysis [10, p.5]: (a) General performance assessment of individual Member States (b) To pinpoint the areas where Member State performance could be improved. (c) To assess whether there is progress over time and (d) to cluster and compare Member States according to their index scores.

**Morgenstadt-Initiative of the Fraunhofer Institute of Industrial Engineering IAO** [6]

The Fraunhofer Institute of Industrial Engineering and its partners of industry and Municipalities worked on "smart solutions" to develop a city based on four pillars measured by 28 indicators[2]:

(a) *Quality of life* which means that the city offers jobs, balances between rich and poor, offers attractive surrounding and public space to meet other people, as well as sustainable environment.

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[2] For the detailed list of indicators see: https://www.morgenstadt.de/de/loesungen/loesungen_staedte/morgenstadt-index.html

(b)     *Resilience* which focuses on stability and preparedness for volatile changes in climate, demographic development, and on the economical basis (Grundlagen)

(c)     *Environmental justice* which pinpoints on alternatives of high $CO^2$ emission within its economy ("$CO^2$- Ausstieg"), and sustainable resource management

(d)     *Innovation* such as encouraging innovation that research institutions and highly qualified employees are attracted by the city. An innovative city offers an "open laboratory" and develops     social     and     technical     innovations     as     well     as     urban     solutions.

The goal of the model was to help municipalities to judge their momentarily situation. Based on the hypothesis that each city is a unique complex system it was not following the idea of benchmarking cities, but to allow each city take a snapshot of their situation to identify a tailored strategy for transforming and developing their city using digitalization. Nevertheless it is possible to use the indicators for a benchmark of cities, because it shows the various urban development processes of municipalities.

**Deloitte Index of Digital Competitiveness of German Municipalities** [11]

The study focuses on the performance and efficiency of municipalities considering digitalization and the digital age since digitalization is the major factor of being competitive within all branches. Therefore it focuses on the factors which encourage and improve digitalization as well as guarantee companies the needed factors. Three areas are analyzed:

(a)     Providing Talents: level and dynamic of employment on the ICT sector, ICT professionals and ICT professions, students in the area of technology, ICT and design, as well as the share of academics of working people.

(b)     Encouraging Innovation: number of research institutes, number of ICT companies, number of start-ups in the digital sector.

(c)     Attractiveness of location: attractiveness for companies and for students.

The study points out that these three areas are essential for a prospering economy. E.g. qualified workforce helps to increase economy based on technical and social innovations, new business ideas and business models, etc. Networking companies and universities guarantee start-ups a perfect location to develop new ideas. Attractive cities even provide an open-minded atmosphere for different kinds of educated people and international exchange.

**Ranking of Cities of Culture** [12]

Attractiveness and diversity of a cultural landscape are aspects of quality of life. Therefore people tend to live and work in cities which offer these aspects. If a city wants to attract highly qualified people it has to focus on them. Additionally attractive and diverse cultural landscape improves the image of a city and has a highly stimulating effect on the dynamism of a town and its economy. The consequence is a cultural industry which itself supports economy in the whole and leads to prospering municipalities. One example of a prospering region because of investments in a cultural infrastructure is the Guggenheim Museum of Bilbao, Spain. The index focuses on different aspects

of cultural life in cities such as visiting cultural events (theater performances, cinemas, concerts, as well as even libraries) differentiating between two indicators: production and reception of culture.

## 3. Consolidated Evaluation Framework of a Smart City and results

Karlsruhe, Stuttgart and Mannheim are three of the cities which were considered in the different studies. Since we wanted to identify the top three smart cities of Baden-Württemberg we selected them considering the following criteria:

(a)     population > 150.000 inhabitants

(b)     existence of universities

(c)     cities which already communicate that they are "smart"

(d)     "Schwarmstadt" – with high attractiveness for people aged between 20 and 34

(e)     Transport system linked to local, regional, national and international transport – public transport, airports, etc. within 25 km

(f)     Cultural facilities such as theatre, museum, etc.

Analyzing the structure and the different levels of structuration throughout the different studies, we noticed that most of the indicators find its pendent cross-reading the studies. So we decided to focus on the areas Smart Economy, Smart Mobility, Smart Environment, Smart Living, Smart Governance and identified seven relevant indicators (see [13], App.B). The weight of each indicator is equal and the assessment of the indicators is based on a scale ranging from 0 to 10 points [13]. So for each indicator a maximum sum of 70 points can be reached within one area.

The following figure shows the results comparing Karlsruhe, Stuttgart, and Mannheim based on the smart areas:

| Area | Karlsruhe | Stuttgart | Mannheim | Means |
|---|---|---|---|---|
| Smart Economy | 23 | 40 | 23 | *29* |
| Smart Mobility | 37 | 27 | 27 | *30* |
| Smart Environment | 28 | 23 | 28 | *26* |
| Smart Living | 40 | 37 | 29 | *35* |
| Smart Governance | 65 | 55 | 55 | *58* |
| **Sum** | 193 | 182 | 162 | *178* |
| **Rank** | 1 | 2 | 3 | - |

**Figure 2: Result of the comparison**

**Smart Economy**

The area of Smart Economy describes the possible increase of economic productivity of a city, if she manages a smart crosslinking of all its stakeholders on the regional as well as the national and international level. Knowledge of the economical regional structure and its composition are the essential key factors to arrange this. Several indicators are considered. E.g. the number of companies which are publicly listed tells us about the attractiveness of the location. The number of part time jobs compared to the number of full time jobs gives an idea about the quality of jobs. The number of part time jobs of qualified employees shows that their potential is not fully used and there might be a lack of competitiveness. Therefore we decided to rate 29 % and more part-time-jobs with 0 points. Highly qualified jobs are indicators for a highly attractive location. Considering the location the Deloitte-Study was used with its two indicators: innovative potential and competitiveness.

| Factor | Indices |
|---|---|
| Innovative spirit | Deloitte Innovation Index & Deloitte Index of Attractiveness; Number of patents |
| Entrepreneurship | Number of Start-ups |
| Flexibility of labor market | Quota of unemployment; share of part-time jobs; share of highly educated jobs. |
| International embeddedness | Number of listed companies |

**Figure 3: Smart Economy – Factors and Indices**

**Smart Governance**

Smart Governance includes a smart public administration as well as smart systems for politicians to decide on policies and politics – such as decision support systems to analyze, to compare and to evaluate areas of policies and politics as well as the impact of decisions. It is also necessary to cope with high complexity and to take citizens along. Major factors are therefore transparent government including Open Data Portals, Online-Participation and an overall strategy for participation.

| Factor | Indices |
|---|---|
| Participation | Emergency plans for natural disasters; Non-currant provisions for natural disasters; Strategy to cope with change of climate |
| Transparent Governance | Open Data Portal; Strategy for participation of citizens; Online-Participation Portal |

**Figure 4: Smart Governance – Factors and Indices**

**Smart Environment**

Within smart environment we focus on environmental protection, pollution reduction and sustainable resource management. These are factors which can be linked to change of climate. Reduction of garbage and energy saving are reducing resource consumption.

| Factor | Indices |
|---|---|
| Environmental protection | Grün- und Wasserflächen im Stadtgebiet |
| Pollution | Greenhouse Gas Emission; Amount of Garbage |
| Sustainable resource management | Share of regenerative energy; Smart Grid Projects; recycling of solid waste |

**Figure 5: Smart Environment – Factors and Indices**

**Smart Mobility**

Smart Mobility describes a city which is working energy-efficient with low emissions, which supports comfortable and reasonable modes of transport while using smart systems for traffic

control. Broadband is the backbone of smart traffic control and therefore is a mandatory precondition.

| Factor | Indices |
|---|---|
| Sustainable & innovative transport systems | Situation of cyclists; number of accidents; mobility safety; number of e-stations; |
| Accessibility | Use of public transport; commuters in % of employed people; number of cyclists |
| Availability of ICT-Infrastructure | Broadband per household |

**Figure 6: Smart Mobility – Factors and Indices**

## Smart Living

Quality of life is the major concern of smart living. So the smart combination of innovative technologies and topics which are relevant for citizens such as Urban Gardening, Smart Home, Smart Health Care as well as cultural programs, education programs etc. are used to increase quality of life. Since the quality of life attracts people and business it is one factor of being competitive.

| Factor | Indices |
|---|---|
| Cultural facilities | International rank as a city of culture |
| Health conditions | Number of hospital beds; Number of doctors; |
| Individual safety | Number of burglars; |
| Housing quality | Rental costs; |
| Education | Quota of students |
| Social cohesion | Poverty rate and poverty quota |

**Figure 7: Smart Living – Factors and Indices**

## 4. Discussion and Future Work

Rankings are one tool to focus on important parameters to judge and to compare the performance and the attractiveness of a city considering major areas. The problem of various rankings lies in their basis which differs. "I only believe in statistics that I doctored myself" "The only statistics you can trust are those you falsified yourself," as Winston Churchill once remarked, shows the problem with rankings and studies [14]. Therefore we decided to have a closer look on cities of Baden-Württemberg in existing studies. So we chose these three cities of Baden-Württemberg to find out if they have really potential for developing in a smart city. This decision led to one limiting factor: We could only consider cities which are already part of a study. So maybe we missed to consider cities which might have had potential of being a smart city but which were not considered in the studies because of other reasons.

The next limitation of our work lies in the selection of areas, factors and indices. As soon as we made the decision to select only some of them, we influenced the result. Maybe the result would be more neutral if we had chosen only indicators mentioned in each study, had clustered them to find out about the factors they support and at last assigned them to the smart areas such as Smart Environment, Smart Governance etc.

At last our approach about assessing the different values of the used indicators of the different studies on the scale of 0 to 10 points might have equaled the real impact of the indicators of a smart city.

Nevertheless our work shows that there is smart city potential in Baden-Württemberg. Since managing complexity and future challenges such as urbanization, use of resources, a rising need for security, changing demographics, etc. which will hit us in the coming years the smart city concept offers various innovative intelligent solutions and brings value to society. So hopefully the cities with smart city potential are supported by the country of Baden-Württemberg as well as federal initiatives. Since Baden- Württemberg (and in general Germany) is far behind other countries when it comes to digitalization and e-government, there is still hope that it can manage to catch up using its potential.

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## APPENDIX A - Consolidated Areas of Smart City Studies

| *European Smart Cities* | *DESI* | *Morgenstadt* | *Deloitte* | *Cultural ranking* |
|---|---|---|---|---|
| Smart Economy<br><br>Innovative spirit<br>Entrepreneurship<br>Economic image & trademark<br>Productivity<br>Felixibility of labour market<br>International embeddedness<br>Ability to transform | Connectivity<br><br>Fixed Broadband<br>Mobile Broadband<br>Speed<br>Affordability | Quality of life<br><br>Poverty rate<br>Unemployment rate<br>Rental costs<br>Medical treatment<br>Lebenserwartung der Baby<br>Einbruchsquote<br>Private cars<br>Use of Public Transport<br>Situation of cyclists<br>Air quality<br>Grün- und Wasserflächen | Talent-Index<br><br>Employment ICT-Sector<br>ICT-Professions<br>Students<br>Share of university graduates | Indicator of cultural production<br><br>Theatre- and Opera-Seats / 1000 citizens<br>Number of exhibitions / 100.000 citizens<br>Public Libraries: current costs / citizen<br>Denkmalschutz-Fördermittel<br>Cinema-Seats / 1000 citizens<br>Students of public Music Schools per 1000 citizens<br>Quota of employees in cultural companies |
| Smart Governance<br><br>Participation in decision making<br>Public and social services<br>Transparent Governance<br>Political strategies & perspectives | Digital Skills<br><br>Basic Skills and usage<br>Advanced Skills and Development | Resilient City<br><br>Share of the 3 biggest companies on employment<br>Independent source of income<br>Dept service ratio | Innovation-Index<br><br>Research Institutes<br>ICT Companies<br>ICT start-ups | Concentration of artists / 1000 citizens<br>Zuwendung öffentlicher Mittel für Kulturproduktion |
| Smart Environment<br><br>Attractivity of natural conditions<br>Pollution<br>Environmental protection<br>Sustainable resource management | Integration of Digital Technology<br><br>Business digitisation<br>e-commerce | Environmental justice<br><br>Greenhouse Gas Emission<br>Share of regenerative energy<br>Amount of Garbage<br>Water usage<br>Recycling of solid waste | Index of Attractiveness<br><br>Attractive for companies<br>Attractive for Students | Indicators of Cultural reception<br><br>Visitors of performances (theatre and opera) / citizens<br>Visitors of museums / citizens<br>User of Public Libraries / 1000 citizens<br>Visitors of festivals / 1000 citizens<br>Sales of cultural companies per citizen<br>Quota of cultural producing companies |
| Smart People<br><br>Level of qualification<br>Affinity to life long learning<br>Social and ethnic plurality<br>Flexibility<br>Creativity<br>Cosmopolitanism / Open-mindedness<br>Participation in public life | Digital Public Services<br><br>e-Government users<br>pre-filled forms<br>online Service Completion<br>Open Data | Innovative City<br><br>Difference of bankruptcies and start-ups<br>Quota of highly educated jobs<br>Number of patents<br>Quota of students | | |
| Smart Mobility<br><br>Local accessibility<br>(inter-)national accessibility<br>Availability of ICT-Infrastructure<br>Sustainable, innovative and safe transport systems | | | | |
| Smart Living<br><br>Cultural facilities<br>Health conditions<br>Individual safety<br>Housing quality<br>Education facilities<br>Touristic attractivity<br>Social cohesion | | | | |

**APPENDIX B - Consolidated Assessment Matrix**

| *Area* | *Factor* | *Indices* |
|---|---|---|
| Smart Economy | Innovative spirit | Deloitte Innovation Index & Deloitte Index of Attractiveness; Number of patents |
| | Entrepreneurship | Number of Start-ups |
| | Flexibility of labour market | Quota of unemployment; share of part-time jobs; share of highly educated jobs. |
| | International embeddedness | Number of listed companies |
| Smart Governance | Participation | Emergency plans for natural disasters; Non-currant provisions for natural disasters; Strategy to copy with change of climate |
| | Transparent Governance | Open Data Portal; Strategy for participation of citizens; Online-Participation Portal |
| Smart Environment | Environmental protection | Grün- und Wasserflächen im Stadtgebiet |
| | Pollution | Greenhouse Gas Emission; Amount of Garbage |
| | Sustainable resource management | Share of regenerative energy; Smart Grid Projects; recycling of solid waste |
| Smart Mobility | Sustainable and innovative transport systems | Situation of cyclists; Number of accidents; mobility safety; number of e-stations; |
| | accessibility | Use of public transport; commuters in % of employed people; number of cyclists |
| | Availability of ICT-Infrastructure | Broadband per household |
| Smart Living | Cultural facilities | International rank as a city of culture |
| | Health conditions | Number of hospital beds; Number of doctors; |
| | Individual safety | Number of burglars; |
| | Housing quality | Rental costs; |
| | Education | Quota of students |
| | Social cohesion | Poverty rate and poverty quota |