A STUDY OF APPLYING SMART CITY STANDARDS ON THE CITY OF ESKIŞEHIR

Fadi ALJERJAWI

Master's Thesis

Department of Computer Engineering

Programme in Computer Engineering

Supervisor: Prof.Dr. Cihan KALELİ

Eskişehir

Anadolu University

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ABSTRACT

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In recent times, the term “smart city” has become widely circulated. This topic is still controversial, and many academics have different interpretations about what a smart city is, so more than one model has been reviewed to reach the broader concept of a smart city. It turns out that the term “smart city” differs from the digital city, the information city, and the sustainable city because it reflects a more comprehensive concept. The researcher discussed the challenges facing smart city initiatives, which can be classified into two main parts: technical challenges and non-technical challenges. A clear model was used for the evaluation. The clear criteria enabled us to measure the performance of the Turkish city of Eskişehir according to the performance of two European cities: Luxembourg, which ranked first in the evaluation of medium-sized European cities, and the Italian city of Naples, which ranked late. The research presents the result of the Eskişehir performance evaluation, identifies its strengths and weaknesses, and proposes measures to improve some aspects. In general, Eskişehir has shown acceptable performance, but there are many points that must be taken care of and developed further in order to obtain a higher evaluation in the future.

Keywords: Smart City, Digital City, Eskişehir, Luxembourg, Naples.

ÖZET

AKILLI ŞEHIR STANDARTLARININ ESKIŞEHIR İLINDE UYGULANMASINA YÖNELIK BIR ÇALIŞMA

Fadi ALJERJAWI

Bilgisayar Mühendisliği Anabilim Dalı
Bilgisayar Mühendisliği Bilim Dalı
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Danışman: Prof.Dr. Cihan KALELİ

Son zamanlarda, "akıllı şehir" terimi geniş çapta dolaşıma girdi. Bu konu hala tartışmalı ve birçok akademisyenin akıllı şehrin ne olduğu konusunda farklı yorumları var, bu nedenle daha geniş bir akıllı şehir kavramına ulaşmak için birden fazla model incelendi. "Akıllı şehir" teriminin dijital şehir, bilgi şehri ve sürdürülebilir şehirden daha kapsamlı bir kavramı yansıttığı için farklı olduğu ortaya çıktı. Araştırmacı, akıllı şehir girişimlerinin karşılaştığı ve iki ana bölüme ayrılabilen zorlukları tartıştı: teknik zorluklar ve teknik olmayan zorluklar. Değerlendirme için net bir model kullanıldı. Net kriterler, Türkiye'nin Eskişehir şehrinin performansını iki Avrupa şehrinin performansına göre ölçmemizi sağladı: Orta büyüklükteki Avrupa şehirlerinin değerlendirmesinde ilk sırada yer alan Lüksemburg ve geç sıralarda yer alan İtalya'nın Napoli şehri. Araştırma, Eskişehir performans değerlendirmesinin sonucunu sunmakta, güçlü ve zayıf yönlerini belirlemekte ve bazı yönleri iyileştirmek için önlemler önermektedir. Genel olarak, Eskişehir kabul edilebilir bir performans göstermiştir, ancak gelecekte daha yüksek bir değerlendirme elde etmek için dikkat edilmesi ve daha da geliştirilmesi gereken birçok nokta vardır.

Anahtar Kelimeler: Akıllı Şehir, Dijital Şehir, Eskişehir, Lüksemburg, Napoli.

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Fadi ALJERJAWI

21/01/2021

STATEMENT OF COMPLIANCE WITH ETHICAL PRINCIPLES AND RULES

I hereby truthfully declare that this thesis is an original work prepared by me; that I have behaved in accordance with the scientific ethical principles and rules throughout the stages of preparation, data collection, analysis and presentation of my work; that I have cited the sources of all the data and information that could be obtained within the scope of this study, and included these sources in the references section; and that this study has been scanned for plagiarism with "scientific plagiarism detection program" used by Anadolu University, and that "it does not have any plagiarism" whatsoever. I also declare that, if a case contrary to my declaration is detected in my work at any time, I hereby express my consent to all the ethical and legal consequences that are involved.

Fadi ALJERJAWI

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GLOSSARY OF SYMBOLS AND ABBREVIATIONS

(S) : Standard deviation

(S^2) : Variation

($\bar{x}$) : Arithmetic Mean

x_i : Value of indicator(i)

1. INTRODUCTION

The need to research this topic arose due to the lack of clarity in the Turkish city of Eskişehir that is a city with a student character and, therefore, has a high percentage of young people, which makes the possibility of using technology in it higher than in other cities. At present, technology has entered most areas of life and is not limited to individuals but has spread to societies to form a broader ground for employing technology to upgrade and develop cities and the possibility of integrating a range of services to work in them in an integrated manner to provide a more comfortable life for citizens.

The main research problem is that the Turkish city of Eskişehir has no manifestations of the smart city even though most of the city's properties qualify it more quickly than others to be a smart city. Therefore, applying smart city standards to the small city is much easier than the big city, and this also applies to the number of residents, which is also considered suitable in the case of Eskişehir, in addition to the rich scientific and cultural presence that this city contains, which makes it a necessity to be a smart city.

Cities worldwide have gone through many historical periods that have formed distinct stages in cities' form and history. Cities have had to respond to the natural development stages over time and in various fields to fulfill the new requirements resulting from this development. At the beginning of the industrial era, new terms appeared that did not exist in the previous era, and with the advent of the information age, new terms appeared that were not known in the era of industry. Cities had many terms, as many terms for cities appeared until we arrived at the term “smart city”.

The term “smart city” was accompanied by many other terms such as digital city, technology-dependent city, virtual city, knowledge city, environment-friendly city, zerocarbon zero-carbon enable city, etc. Most of these terms converge at a certain point or more. More than that, all cities worldwide, whether they belong to developed countries or not, contain a certain amount of city intelligence, even if it is simple. Wired and wireless networks are considered one of the basics for employing intelligence in cities. Those networks also include the mobile phone networks in all countries of the world and constitute a significant ground for imparting a kind of intelligence to cities. In all countries, cities are considered the largest place for human gatherings, and therefore, cities are the

engine of economic growth, development, and innovation. (Abdoullaev, 2011) argues that what defines the city is its ability to gather people, capital, talent, government agencies, infrastructure, physical or social, and public services. According to the Azamat, this will guarantee the success of research, plans, and academic conferences aimed at reaching the smart city project, turning it into actual strategic plans for governments to implement on the ground, and expecting smart cities to turn into significant places of well-being and prosperity.

1.1. Smart Cities

The rapid development that the world is witnessing in all areas of life, especially in the other two decades, makes the topic of smart cities a severe challenge for countries rather than just a luxury, where daily the need becomes more urgent in order to make the current cities able to respond and interact with technological development. In the growing, it can be seen that the majority of cities around the world are now heading towards smartness, whether this is within an organized plan or not because it has become a part of our daily life. However, in different proportions, of course, this matter is due to the city's nature, the way it is designed, and the infrastructure is built there and how its ability to respond to changes. This technological development contributes to the emergence of new concepts of society such as the term knowledge society or digital society, where it is natural for the development of social behavior to be consistent with the development of cities performance, and we can consider that the development of cities came to meet the needs of the development of society.

The trend towards smart cities contributes mainly to addressing many contemporary problems and can be considered a critical element in promoting the sustainability process by establishing sustainable smart cities or introducing sustainability standards in existing cities.

1.2. Challenges of Smart City Initiatives

Given the number of literatures that has discussed the topic of the smart city and the issue of challenges facing smart city initiatives, which is few, the challenges facing smart city initiatives fall into **two main parts** (Pierce & Andersson, 2017):

The first section is technical challenges: It discusses the topic from a technological point of view. Most of the challenges in this aspect were related to the use of technology and the consequent concerns of breaching privacy due to the tremendous detailed information emanating from such initiatives and the emergence of security concerns.

Another main technical challenge is interoperability because smart city projects require a high degree of coordination and information exchange between several different frameworks.

The second section is non-technical challenges: the issue of cooperation represents one of the most prominent challenges facing smart city initiatives, and it is clear that cooperation between the various administrative authorities concerned with smart city initiatives faces problems in many cases, and it may be in the form of different visions about city development. Uncoordinated efforts fall under the category of challenges, which leads to wasting time.

One of the significant challenges in this context is the financial aspect, as it is known that smart city initiatives require high financial costs, something that cannot be available in all cities.

1.3. Terms Related to Smart City

- **Digital city:** Komninos considered the term digital city as a comprehensive, webbased electronic representation for carrying out the usual tasks in cities which are performed by ordinary city dwellers in multiple fields including work, commerce, education, health, etc.(Couclelis, 2004).

According to (Komninos, 2006)*, (Sadek, 2013)*, there are four types of digital cities:

- ✦ Digital economic cities are mainly concerned with economics and economic information, and their goal is to profit for their individuals.
- ✦ A digital government city is a digital simulation of a city established to enhance communication between government agencies and citizens.
- ✦ Virtual city: an example of which is the virtual city of Helsinki project. This virtual city offers virtual tours within the city that have been represented by using 3D technologies, and the virtual tour in the city includes discussions between citizens and service providers.

- ✦ A multi-purpose digital city: this virtual city provides information on traffic, weather, shopping, and parking and allows citizens or visitors to make interactive virtual tours within the city. The multi-purpose digital city is the most advanced of the four types.

The digital city contains four layers: information storehouse layer, application layer, user interface layer, and administrative layer.

It can be said that the term digital city is very similar to the term digital transformation, and this became clear in (Tomičić Pupek, Pihir, & Tomičić Furjan, 2019), and the digital city can be considered a state resulting from digital transformation.

- **Knowledge city:** It is a city that has been purposefully designed to encourage knowledge nurturing.

Knowledge cities focus on information and communication technology to increase the exchange of knowledge and experience between individuals. The knowledge city can be considered a product of the knowledge economy and the information society (Radovanović, 2004).

Knowledge cities are concerned with developing the creative skills of community members to support business and education.

According to *(Reffat, 2005)*, the city of knowledge offers a set of advantages, including:

- ✦ Providing real job opportunities with good returns
- ✦ Providing a progressive development index for both income and national product
- ✦ Adopting creative thinking in society
- ✦ Connecting universities, schools, and research centers networks ✦ Facilitating access to technology for community members

- **Sustainable city:** As a response to the deterioration in the environment after the expansion of industrial activities tremendously throughout the twentieth century,

the idea of a sustainable city began to appear as a political initiative in the beginning *(Saha & Paterson, 2008)*. **"**The UN sustainable city program has defined the sustainable city as one that can retain the supply of natural resources while achieving economic, physical, and social progress, and remaining safe against the environmental risks that can undermine any development achievement"(Hassan & Lee, 2015) .

The three previous examples give us an idea of the areas that the three mentioned cities are interested in. For example, the **digital** city focuses on the digital side and the employment of technology in the city's facilities, but it does not pay equal attention to other aspects of the city, such as the environmental aspect. The city of **knowledge** focuses on the knowledge aspect more than other aspects, as well as the **sustainable** city focuses on the environmental aspect of the city more than other aspects.

1.4. Smart City Definitions

The vast majority of definitions share everyday things, and some are influenced by factors such as the period in which the definition appeared and the reasons that made cities move towards a smart city.

Droege (1997) linked the concept of a smart city and a virtual city and included many terms under the virtual city, such as the digital city, the information city, the knowledge city, and other cities, but linked them to the virtual city, and we can notice that the following definitions will be more accurate because it is old.

Dameri (2017) considered a smart city to be a specific geographical area in which advanced technologies cooperate to achieve benefits and well-being for citizens, governed by well-defined topics that have the ability to define local government policies.

Komninos (2006), Komninos (2002) says that the term smart city is given to regional systems that are distinguished by creativity, which combines the cognitive efforts aimed at developing creativity and education and the digital means that develop the use of technology in order to enhance the ability to face the challenges facing the city. He considered that outstanding performance in creativity is one of the essential elements in the smart city.

Geller (2003) believes that a smart city is a city with good performance and ambition in the fields of economy, mobility, environment, governance, and people. He believes that these determinants should be based on an intelligent combination of talent and awareness of citizens. (Steventon & Wright, 2010) believe that the term smart city refers to smart environments that use ICT to create an interaction between digital and physical spaces.

Komninos (2007) considered that the smart city is the regions that provide ICT as well as innovation systems for the local community in order to enhance the creativity capabilities in society and facilitate knowledge management; that is, it combines the intelligence of both individuals and institutions that encourage innovation.

The forum stipulated the availability of several conditions that should be met in the smart city, which are the a) provision of broadband communication services, b) ensuring that all members of society benefit from technologies and this requires the distribution of digital services, c) focusing on practical education and training, d) enhancing creativity in the public and private sectors, e) providing financing for development by establishing economic groups for financing, and f) achieving economic development that encourages attracting skills and competencies (Sadek, 2013), (Komninos, 2007)

Nam and Pardo (2011) believe that the city can be smart when human and social capital and infrastructure that includes transportation and communication improve the quality of life and achieve sustainable economic growth through sound resource management overseen by a participatory governance system.

Abdoullaev (2011) considered that a smart city is an urban agglomeration that guarantees the existence of three main pillars: the city of knowledge, the city of environmental sustainability, and the digital city. Azamat considered that each of these three could not be considered a smart city by itself and considered a smart city that should include a digital city, a city of knowledge, and a sustainable environmental city in an integrated model. Azamat's approach to the smart city's issue was remarkable as he focused on blending the three elements: the environment, people, and information in one mixture that works within a unified and harmonious system.

Caragliu, Del Bo, Kourtit, and Nijkamp (2009) believe that smart growth is not a means of transportation, but rather a mindset for creating a more inclusive smart society and thus a smart city. They also focused on the issue of inclusiveness.

According to (Batty et al., 2012), the smart city is deeply involved in establishing smart infrastructure and creating connections between ICTs and humans. Thus, this requires smart growth.

According to (Silander, 2019), smart growth must respect three points: sustainability, smartness, and inclusiveness. Sustainability should be in the environmental aspect, and concerning intelligence, they mentioned economics and governance, and about inclusiveness, they mentioned social and regional cohesion.(Davidson, 2010) considered that a smart city is a city that uses information and communication technology (ICT) to improve productivity and achieve more governance in urban planning. (Trencher & Karvonen, 2019) criticized the ideal language used on the smart city topic as a solution to all problems, and considered that most of the projects related to the smart city and sustainable health city do not benefit human health despite the beautiful hypothetical talk on the subject.

Based on those mentioned above, we notice the differences in the smart city definitions, and we also note that these definitions share many unanimous points. Furthermore, by looking at the academic works that dealt with this topic, the researcher believes that the smart city should represent the smart city's three main aspects: the digital aspect, environmental aspect, and the knowledge aspect.

The researcher believes that smart city projects' primary goal is to facilitate residents' lives and provide a more comfortable lifestyle. Consequently, many commercial projects do not consider this primary point as a priority but instead focus more on their projects' marketing and commercial purposes, which puts companies' interest ahead of the citizen's interest.

The researcher agrees with the academic works that focused on the goal behind the smart city projects, which provided a realistic picture of what a smart city should be, other

than the rhetoric promoted by some technology companies, which makes the listener thinks that the smart city is a city coming from space.

Therefore, the researcher believes that a smart city can be defined as follows: **It is a city that employs information and communication technology to facilitate the citizen's life in various fields within a unified system along with achieving environmental and knowledge sustainability**. Thus, the smartness employment rate varies from one city to another.

It is clear from the previous definition that it is challenging to consider any city as being not a smart city, but rather a city that contains some kind of smartness in a particular part and lacks smartness in certain areas that should be highlighted. This belief is that one of the most critical infrastructure factors in smart city projects is the communication networks and the Internet, which are available in most cities around the world.

1.5. Layers of a Smart City

Komninos (2008) believes that a smart city consists of a multi-layered system and contains **three layers** of intelligence that complement each other.

The first layer is the individuals, and it is considered the main layer and consists of city residents and, more specifically, those who can creatively produce in the field of manufacturing and city development projects, and groups working in production and services. The process of exchanging information and experiences between individuals in this layer is essential, and we notice that cities compete in attracting talent and genius minds.

The second layer includes institutional mechanisms for knowledge creation and social cooperation in technology and innovation. Institutions interested in research and development, such as research centers, technology, intelligence institutions, and investment capital, are prime examples. There must be a collaborative space between these institutions and the various gatherings to achieve the most significant benefit from the innovation process. The strong presence of these institutions is a critical factor in strengthening this class and social capital.

The third layer consists of electronic services and digital networks that facilitate the innovation process, considering the infrastructure for information and communication technology. This layer relies heavily on multimedia tools and interactive means and works within several paths to reach innovation.

It is worth noting that each of these three layers must complement each other, as no layer will be effective when working separately. As far as these layers are concerned, it is necessary to ensure their work's effectiveness by assessing their ability to be creative and solve problems that appear creatively. Therefore, Komninos considered that the smart city is a regional creative system.

1.6. Dimensions of A Smart City

- Smart Economy (Competitiveness)
- Smart Governance (Participation)
- Smart Environment (Natural Resources)
- Smart People (Social and Human Capital)
- Smart Mobility (Transport and ICT)
- Smart Living (Quality of Life) (Giffinger, Fertner, Kramar, & Meijers, 2007)

1.7. Research Methodology

Given the nature of the study, its subject, the research problem, and the goals that the research seeks to achieve, the most appropriate way to accomplish the research is the **descriptive-analytical method** that collects information and the necessary data to diagnose the problem through databases, scientific papers, and the Internet, documents and references, books and articles, maps and photos.

The descriptive-analytical method is one of the most critical research methods due to its frequent use and critical role in many studies and research types. It is expressed in two ways. The first is the qualitative type, as a clarification of its properties. The second is the quantitative type by giving it a numerical description that explains the amount of the described phenomenon or the ratio of its association with other phenomena. It should be noted that the descriptive approach is a broad and flexible umbrella due to including several other sub-curricula, such as the social survey or case study approach. Thus, after reviewing the definition of the descriptive approach, it can be said that it is the master of the

curriculum. Because it almost covers all curricula except for historical and experimental aspects. The reason is that the description is based on clarifying any idea or study and is common to all studies. The analytical method helps reach more accurate results through fragmentation, division, and evaluation of the problem and delving into the interpretation. That means that the analytical approach's foundations complement the procedures of the descriptive approach or other scientific approaches.

1.8. Research Tools

To achieve the research objectives, the researchers used a set of tools, including official databases, scientific literature related to the topic of the research, books, references, websites, and data related to the cities of Eskişehir, Luxembourg, and Naples (Napoli).

All indicators that describe the factors of a smart city are derived from public and freely available data, mainly obtained from the following databases:

- Urban Audit database
- Eurostat database
- Espon database
- Italian National Institute of Statistics (Istat)
- Statistics Portal - Grand-Duchy of Luxembourg

The primary sources for data collection for Eskişehir are as follows

- Türkiye İstatistik Kurumu (TÜİK) - Eskişehir İstatistikleri online book
- BEBKA - Bursa Eskişehir Bilecik Kalkınma Ajansı

It should be noted that some values have been represented at the regional level and some at the state level because they are only available in this way.

1.9. Contributions

The research's main objective is to develop clear recommendations to transform the Turkish city of Eskişehir into a smart city by identifying the tools, procedures, and interventions required for this transformation in all critical areas. To achieve this primary

objective, it is necessary to achieve a set of sub-goals first in order for the construction process to be progressive and precise. These sub-goals are:

- Clarifying the concept of a smart city and its main components.
- Checking the feasibility and effectiveness of transforming existing cities into smart cities in exchange for the voices calling for creating smart cities from scratch.
- Explaining the methods adopted in the standards for measuring the performance of cities
- Determining the most appropriate method to deal with Eskişehir
- Providing an accurate description of the current state of Eskişehir in terms of intelligence.
- Providing the necessary recommendations to consider Eskişehir as a smart city.

2. LITERATURE REVIEW

A. Smart cities-Ranking of medium-sized European cities

The research has been done by collaborative work of persons from the Centre of Regional Science at the Vienna University of Technology, Vienna/ Austria, October 2007.

Rudolf Giffinger, Christian Fertner, Robert Kalasek, Nataša Pichler Milanović.

TU Wien. The University of Copenhagen. TU Wien. The Academic and Research Network of Slovenia.

The research began by clarifying the smart city concept; then, the research presented a set of foundations and criteria for evaluating and classification smart cities. The research considered the smart city as the city with good performance in six characteristics, and each of these six characteristics has a set of factors that define it. The research sees that these six characteristics can Consider a city as smart based on it: Smart Economy, Smart People, Smart Governance, Smart mobility, Smart environment, and Smart living. Then the research presents a methodology for determining the cities to be evaluated, as it dealt with medium-sized European cities. The research considers the development challenges in each of them, and 13 cities were chosen based on a set of indicators, including population, the availability of one university at least in the selected cities, and easy access to private data in each city.

It is also identified a set of factors and indicators for the evaluation, which were chosen based on the concept of smart cities; and this evaluation included 31 factors, and each factor was clarified through a set of indicators that reached 11 indicators.

The research provides a set of statistical and graphical analyses for a set of urban data to analyze the factors that determine medium-sized smart European cities' performance. Through this evaluation, each city is given a value for intelligence and defines future development goals and strategies.

B. Smart cities in Europe

"Smart cities in Europe," 3rd Central European Conference in Regional Science, "Andrea Caragliu, Chiara Del Bo, Peter Nijkamp", Slovak Republic, 2009.

Politecnico di Milano, Piazza Leonardo 32, 20133 Milan Italy. Università degli Studi di Milano, Via Conservatorio 7, 20122 Milan Italy. VU University, De Boelelaan 1105, Amsterdam 1081 HV, The Netherlands.

This research deals with the definition of a smart city. It considers that the majority of the definitions on the Internet are biased for communications, as most depend on the communication infrastructure, and believes that the reason for this is the impact of definitions on the period where the concepts of smart cities spread in the nineties in conjunction with the beginning of the spread of communication networks in cities.

This research also builds its definition on the six axes used in the previous research. The research considers that these axes are based on theories of regional competitiveness, transport and ICT economics, natural and social resources, and human and social capital.

The research believes that the city is smart when all human and financial capital interfaces with the transport infrastructure and the ICT infrastructure to achieve sustainable economic growth and a higher level of life, and better management of natural resources. The research believes that human and social capital may be more important than physical capital in the smart city's competitiveness. The research attempts to find a data set in order to analyze the factors that determine the performance of smart cities, and The research finds that there is an innovative category in addition to interest in education and the urban environment, the use of information and communications technology for public administration positively linked to urban wealth. The research urges the formulation of a new strategic agenda for smart cities in Europe to achieve better sustainable urban development results.

C. A Smart World: A Development Model for Intelligent Cities

Azamat Abdoullaev

Ph.D., Managing Director. EIS Encyclopedic Intelligent Systems Ltd (EU; Russia)/ Smart Sustainable Community Int. Group (The Smart Group).

The 11th IEEE International Conference on Computer and Information Technology (CIT2011)

The research discussed justifications for the emergence of smart cities and provided answers to the strategies, standards, and technologies used to develop cities. The research also discussed the challenges and facilities facing cities' development and discussed an important issue: the differences between smart city projects and models worldwide.

The research believes that no integrated smart city combines sustainability, economics, and technologies and reviewed many smart cities models that research said are not

integrated or fragmented and discussed the concept of an actual smart city that must be integrated.

The research finds that using intelligence on all city components, such as education, transportation, energy, the health sector, buildings, infrastructure, and security, is not sufficient to consider the city as a smart city. The research also believes that using smart applications in a piecemeal manner is not sufficient to establish smart cities without integrated regional urban planning, and the research considers smart cities to be the starting point for reaching a sustainable smart world .

The research showed that the concept of the sustainable smart city is consistent with the strategy set by the European Union for the year 2020, which is smart growth, sustainable growth, and comprehensive growth, also identified a set of characteristics that must be available in the smart city, which are sustainable strategies, virtual reality, creativity and knowledge, technical complexes and research and development centers.

The vision of this study is that the smart city is based on three main pillars. The city cannot be considered smart if one of these three elements is not implemented. The three pillars are: Digitally smart, Sustainable environmental city, Socially smart city

D. THE ARCHITECTURE OF INTELLIGENT CITIES (Integrating human, collective and artificial intelligence to enhance knowledge and innovation)

Urban and Regional Innovation (URENIO) Research Unit, Aristotle University of Thessaloniki, Greece, 2006.

The research finds that discussions related to smart cities and communities are fed through two main sections: the literature on innovative environments and digital city planning.

The research says that a digital city is the predominant form of community space corresponding to a region. The research believes that digital cities cover an extensive range of digital networks and software applications that facilitate multiple aspects of the cities' social and economic life: commerce, transactions, security, health, education, work, entertainment, transportation, and more. Moreover, the author cites the opinion of writers

who have written important books on smart cities, saying that the concept of a digital city is just a linguistic metaphor (Ishida, 2000a), (Ishida, 2000b), (Tanabe, Van den Besselaar, & Ishida, 2003).

E. Smarter Cities, The Social Nexus-Scientific American

Carlo Ratti[1], Anthony Townsend[2] [1]

Teaches at the Massachusetts Institute of Technology's department of urban studies and planning, [2] Research Director at the Institute for the Future, a Palo Alto, Calif, He is writing a book about the future of urbanization and computing for W. W. Norton in Turin, Italy, September 2011

The research focuses on the significant role that society plays in the smart city, as the researchers considered that there are two types of smart city, the first type which is from top to bottom which is very similar to creating an entire city from scratch. The second type is from the bottom up, which is about recruiting technology in favor of Existing cities to upgrade their smart performance.

The research finds that the citizens' phones can be harnessed as live sensors to improve the city's services, and he considered this a logical and less expensive solution than creating areas filled with thousands of sensors at an expensive cost.

The research tends strongly to the pattern that adopts a bottom-up approach to introduce technology to existing cities for several reasons, including that the enormous cost of creating a city from scratch may not meet the people's continuous and changing needs like cities design. The research adds that the biggest problem facing this pattern is what people want. The researchers believed that this methodology would be fragile to change and would be subject to failure as previous similar projects had failed due to designers' faulty assumptions about how residents expect to incorporate technology into their daily lives.

The researcher believes that the behavior of people is a decisive factor in transforming a city towards intelligence. He also believes that each city has its peculiarity in applying its own intelligence experience, which is not necessarily suitable for implementation in another city.

The research stresses that the centralized approach existing in smart cities that are created from scratch as a Masdar City in the United Arab Emirates suffers from shortcomings, and the research refers to the critical importance of integrating the natural development of people's behavior to use smart techniques and employing these techniques to make life in the city easier.

F. International Case Studies of Smart Cities, Songdo Republic of Korea

Sang Keon Lee, Heeseo Rain Kwon, HeeAh Cho, Jongbok Kim, Donju Lee

Joint Research: Korea Research Institute for Human Settlements in association with the Inter-American Development Bank, 2016

This study is one of ten case studies conducted by the Korea Research Institute for Human Settlements in association with the Inter-American Development Bank.

The city of Songdo in South Korea was taken as a case study as the world's newest and smartest city.

The city's construction began from scratch in the year 2008 as part of a free economic zone that attracts many of the most important commercial and technical events around the world.

This study sheds light on the six main areas in Songdo: transportation, security, disasters, environment, citizen interaction, and topics related to home, education, and health. The study clarified each of the mentioned sectors' mechanism of action and showed the strength of the system in place within the city. The study says Songdo is working to become a smart city icon by employing unique smart services.

The study showed the importance of the partnership between the public and private sectors, as it said that one party would not be able to implement a comprehensive vision at the city level except through partnership with various sectors.

2.1 Purposes of Research

Previous literature discussed the concept of a smart city, the justifications for the emergence of smart cities, and the factors that increased the sustainability of cities and tackled the criteria adopted to measure cities' performance. It also considered that a set of factors together contributes to determining the city's ability to compete within the race of

intelligence between cities. It also discussed the ongoing disagreement over the effectiveness of creating smart cities from scratch or investing in existing cities and then analyzed cases of smart cities created from scratch.

Previous studies answered many questions, including:

- What are the opportunities and challenges facing smart cities?
- What are the standards and strategies used in urban development?

How can a city's smartness performance be measured, and what are the factors that affect it?

- Evaluating the performance of European and international cities (no Turkish cities)

What distinguishes this research is its study of the case of a Turkish city, which was not mentioned in previous literature, the study of the possibility of applying the standards adopted in medium-sized European cities to the city of Eskişehir given that there are many similarities which gather Eskişehir in medium-sized European cities.

The researcher mainly focused on making the lives of residents in the city of Eskişehir as easy as possible, as it has become necessary to contribute to creating social behavior that has the skill to deal with the requirements of the tremendous acceleration in the technological development that the world has witnessed during the past years. By this, we can raise awareness of people and society. The research also contributes to supporting the future trend towards sustainable cities that reduce energy-dependent use on non-renewable resources and reduce thermal emissions and contribute to waste recycling and air purification.

3. SMART CITIES PERFORMANCE EVALUATION MODELS

This section will discuss what is related to the global standards for ranking smart cities' performance, the most famous of these standards will be identified and compared between them, and the best and most appropriate ones will be selected for adoption in the city of Eskişehir. The criteria for evaluating cities' performance mainly aim to identify the exact

situation of smart cities and identify weaknesses and strengths, which would guide the development process on its right track.

3.1 Introduction

City rankings play an important role in assessing the attractiveness of cities and their ability to meet aspirations. The classifications examine the social, economic, geographic, and technological aspects of cities. Benefits of cities evaluation (Giffinger et al., 2007):

- It constitutes an important entry point for developing strategies and plans.
- Stakeholders are encouraged to implement transparency.
- Encouraging investment in development.
- Identify strengths and weaknesses.
- Contributes to raising awareness of the city population.

The criteria for evaluating cities' performance are an effective way to increase competitiveness between cities, which leads to a race in the process of developing cities. There are four types of rankings for city performance evaluation criteria (Giffinger & Gudrun, 2010).

The first type is commissioned economic rankings, which usually tend to be economically oriented. This type has a transparency problem as the used indicators or data sources are not mentioned, and the method of calculation used is unclear, which gives inaccurate results.

The second type is commissioned rankings, which has a problem of transparency as it is mostly supervised by private institutes and lacks clarity in selecting samples and the method of calculation followed is unclear. Often, the sponsors of this research are financial institutions or real estate agencies.

The third type is the rankings of journals and non-governmental organizations, in which samples are chosen in a relatively precise manner, and the method of calculation is explained, and the data used is transparent.

The fourth type is rankings conducted by research institutes and universities in conjunction with sponsors in many fields. These classifications are well-documented,

usually, focus on a specific area, have clear criteria in selecting the sample, and the method of calculation used is considered the best among other rankings. Also, it has a high degree of transparency, and its results are detailed and precise.

The following table shows the difference between the characteristics of typology

Table 3.1. *Types of Evaluation in General. Source: (Giffinger & Gudrun, 2010)*

	Type 1	Type 2	Type 3	Type 4
Number of rankings	3	3	4	8
Transparency of ranking calculation	very bad	bad	good	very good
Documentation of data base	very bad	bad	very good	very good
Number of indicators[7]	32	43	51	29
Spatial dimension	worldwide	varying	country / continent	country / continent
Number of cities[8]	60	75	25	54
Transparency of city-sample selection	very bad	bad	very good	very good
Elaborateness of results[9]	2,17	2,67	2,75	2,62

3.2 Model of Intelligent Community Forum (ICF)

This Criteria developed by the Smart Society Forum to assess smart societies (Komninos, 2007).

1. The widespread deployment of broadband communications like the government's facilities networks and companies requires government support and incentives to encourage its spread and work to organize it according to a unified framework.
2. Effective education and investment of human resources: It includes the quality of education and training to raise the workforce's efficiency and work to create a class of scientifically qualified to lead the knowledge efforts.
3. Programs supported by the government and the private sector: They aim to enhance citizen participation in decision-making. This requires work to encourage the use

of technology in order to ensure the participation of the largest possible number of citizens in the decision-making process.

4. Encouraging innovation: It includes initiatives to develop or create new businesses that stimulate economic growth in society. It also includes e-government initiatives.
5. Marketing: It aims at attracting investments, capital, and human resources in order to achieve the required economic growth.

This ranking is concerned with the complementary relationship between innovation, knowledge, communication networks, and the economy. The ranking aims to measure individual cognitive performance and its impact on society through these societies' ability to provide an environment that stimulates innovation and investment. It is also concerned with evaluating the effectiveness of governmental and private programs that aim to enhance citizen participation in decision-making and programs to spread democracy in society.

This ranking was applied to 40 cities worldwide, and there was a clear difference in the characteristics of the selected cities. Among the disadvantages that are taken on this classification is the failure to accurately define the segment of the target cities sample, as the list of cities contained a heterogeneous pattern of cities such as urban cities and rural cities, which also contained tens of thousands population, and other cities contained millions.

Conclusion: This ranking is not valid for application to the city of Eskişehir due to its failure to follow criteria that take into account the specificity of the selected cities and not give detailed results as required.

3.3 Model of Nicos Komninos and Eleni Sefertzi

Researchers Nicos Komninos and Eleni Sefertzi reached forty indicators to assess the performance of smart cities. The forty indicators were distributed on four main axes (Komninos & Sefertzi, 2009).

- **Education and people skills, including the percentage of:**

1. Holders of tertiary education from the population (11-21 years).
2. Participation in life-long learning (25-64 years).
3. New Graduates of Science and Engineering (20-29)

4. Researchers in industry and services (from the workforce).
5. Researchers in the public sector (from the total number of researchers).
6. Researchers in the private sector (from the total number of researchers).
7. Employment of tertiary-level graduates (from the total number of employment).
8. Employment in medium and high-technology manufacturing (out of total workforce).
9. Employment in high-tech services (from the total of the workforce).
10. The creative class (workers in the creative industries).

• **Creativity and knowledge institutions, including the percentage/per million of:**

1. The number of university students (of the total population).
2. Number of university staff (per million of the population).
3. Total research and development expenditures (of GDP).
4. Public spending on research and development (gross domestic expenditure on research and development as % of GDP).
5. Business spending on research and development (business enterprise expenditure on research and development as % of GDP).
6. Business spending on licenses (of turnover).
7. The number of incubators (per million people).
8. The number of science and technology parks (per million people).
9. The number of technology transfer and innovation centers (per million people).
10. Venture capital funding (of total trade finance)

• **Digital infrastructure and e-services:**

1. City area covered by cable networks (% of total area)
2. City area covered by Wi-Fi networks (% of total area)
3. City area covered by xDSL networks (% of total area).
4. Computers (per million of the population)
5. Internet connections (% of the population)
6. Broadband connections (% of the population)
7. Users of e-gov services (% of the population)

8. City enterprises owning a website (% of total enterprises) 9. City enterprises involved in B2B or B2C (% of total enterprises)
10. Digital service providers (% of ICT companies).

• **Innovation performance**

1. EPO patent applications (per million of the population)
2. New trademarks (per million of the population)
3. Innovative enterprises manufacturing (% of all manufacturing enterprises)
4. Innovative enterprises services (% of all services enterprises)
5. Enterprises having internal R&D department (% of all enterprises)
6. Sales of new-to-market products (% of turnover)
7. Sales of new-to-firm, not new-to-market products (% of turnover)
8. New companies' creation (% of total enterprises)
9. Exports high-tech products (% of total exports)
10. Exports high-tech services (% total exports)

These standards address four aspects, namely skills, digital spaces, knowledge, and innovation institutions. It is noted that three of the four are related to inputs, and only innovation is related to outputs. To measure the progress made in each of the four corners, a four-dimensional radar chart is made, and it is also noted in this classification that the strategies that succeeded in one place do not necessarily succeed in another place.

3.4 Model of IESE

These are standards developed jointly by the Center for Globalization and Strategy and the Department of Strategic Management at IESE (Instituto de Estudios Superiores de la Empresa) College.

These criteria are based on 101 indicators distributed on nine main axes, as follows (Ricart. & Berrone, 2020):

- **Human Capital**

  This axis contains indicators related to education, the number of private and public schools, business schools, the number of universities, its studies individuals' leisure activities, the state of arts represented in museums and exhibitions, and the number of visitors.

- **Social Cohesion**

  This axis is concerned with empowering women and measuring the extent of their integration into the labor market. It is concerned with the societal aspect represented in crime rates, homicide, suicide, terrorism, and peace issues. It also discusses the issue of slavery, unemployment, and genetic distribution in society.

- **Economic**

  This axis is concerned with the smart city's performance from the economic side, as it studies the purchasing power and the extent of the ability to establish new businesses, the number, quality, and branching of companies. It also studies the wage for the hour of work and measures the gross product per capita.

- **Governance**

  This axis is concerned with studying the smart city from a governance perspective. It studies the state of e-government and the extent of its use in society and the democracy index. Also, it studies the number of embassies in the city, the number of public sector employees and studies the corruption index in the city, and the per capita share of precautions. This axis also studies research centers and their numbers in the city.

- **Environment**

  This axis is concerned with studying the smart city's environmental aspect, including pollution, carbon dioxide emissions, and methane gas, and studies the state of the climate and its future. It is also concerned with solid waste, water sources, and the number of particles in the air .

- **Mobility and Transportation**

This axis studies the state of transportation and mobility in the smart city and focuses on the individual aspects of mobility such as bicycles, scooters and moped, and their availability and ease of use, including rental rates. This axis also studies the performance of traffic and measures its efficiency. It also studies collective transportation, such as the express train, the metro, and the number of available stations. It also studies the number of incoming and outgoing air flights.

- **Urban Planning**

This axis is more concerned with the smart city's urban aspect, including the buildings, distribution, height, and the number of residents of each house. It also includes the number of residents benefiting from sewage networks and the number of bicycle points allocated for rent and the number of bicycles. It shares this indicator with the transportation and mobility axis.

- **International Projection**

This axis is concerned with studying international communication of the smart city, including the number of users of the city's airports and the number of hotel guests in the city. It also includes the number of pictures of the city uploaded on the Internet and a comparison between the prices of restaurants and bars in the city and their prices in New York City. This axis is also considered the number of McDonald's restaurants in the city, an index within the urban planning indicators. Finally, it studies the number of international meetings and conferences in the city.

- **Technology**

This axis contains the largest number of indicators in the nine axes of this assessment. It studies the extent of technology presence in the smart city, including the number of citizens who receive 3G internet coverage, the number of computers relative to the city’s population, the number of homes connected to the internet, and the extent of use Internet in banking transactions. It studies the availability of the Internet, its speed, and the services associated with it on many platforms. It also studies the number of landline phone lines and the innovation index.

3.5 Model of Centre of Regional Science at The Vienna University of Technology

This model is a collaborative work of persons from the Centre of Regional Science at the Vienna University of Technology (lead partner), the Department of Geography at the University of Ljubljana, and the OTB Research Institute for Housing, Urban and Mobility Studies at the Delft University of Technology. The structure of this assessment is based on a hierarchical system. There are indicators, factors, then characteristics at the base and the top of the hierarchy are the smart cities.

This evaluation contains six characteristics,31 factors which contain 74 indicators are included under them as follows (Giffinger et al., 2007):

1. Smart Economic

1.1 Innovative spirit

1.1.1 R&D expenditure in % of GDP

1.1.2 The employment rate in knowledge-intensive sectors

1.1.3 Patent applications per inhabitant

1.2 Entrepreneurship

1.2.1 Self-employment rate

1.2.2 New businesses registered

1.3 Economic image & trademarks

1.3.1 Importance as decision-making center (HQ etc.)

1.4 Productivity

1.4.1 GDP per employed person

1.5 The flexibility of labor market

1.5.1 Unemployment rate

1.5.2 The proportion of part-time employment

1.6 International embeddedness

1.6.1 Companies with HQ in the city quoted on the national stock market

1.6.2 Air transport of passengers

1.6.3 Air transport of freight

2. Smart People

2.1 Level of qualification

- 2.1.1 Importance as knowledge center (top research centers, top universities etc.)
- 2.1.2 Population qualified at levels 5-6 ISCED
- 2.1.3 Foreign language skills

2.2 Affinity to lifelong learning

- 2.2.1 Book loans per resident
- 2.2.2 Participation in life-long-learning in %
- 2.2.3 Participation in language courses

2.3 The social and ethnic plurality

- 2.3.1 Share of nationals born abroad

2.4 The social and ethnic plurality

- 2.4.1 Share of foreigners
- 2.4.2 Share of nationals born abroad

2.5 Flexibility

- 2.5.1 Perception of getting a new job

2.6 Creativity

- 2.6.1 Share of people working in creative industries

2.7 Cosmopolitanism/Open-mindedness

- 2.7.1 Voters turnout at European elections
- 2.7.2 Immigration-friendly environment (attitude towards immigration)

2.8 Participation in public life

- 2.8.1 Voters turn out at city elections
- 2.8.2 Participation in voluntary work

3. Smart Governance

3.1 Participation in decision-making

- 3.1.1 City representatives per resident
- 3.1.2 The political activity of inhabitants

3.1.3 Importance of politics for inhabitants

3.1.4 Share of female city representatives

3.2 Public and social services

3.2.1 Expenditure of the municipal per resident in PPS

3.2.2 Share of children in daycare

3.2.3 Satisfaction with quality of schools

3.3 Transparent governance

3.3.1 Satisfaction with the transparency of bureaucracy

3.3.2 Satisfaction with the fight against corruption

4. Smart Mobility

4.1 Local accessibility

4.1.1 Public transport network per inhabitant

4.1.2 Satisfaction with access to public transport

4.1.3 Satisfaction with the quality of public transport

4.2 (Inter-)national accessibility

4.2.1 International accessibility

4.3 Availability of ICT infrastructure

4.3.1 Computers in households

4.3.2 Broadband internet access in households

4.4 Sustainable, innovative, and safe transport systems

4.4.1 Green mobility share (non-motorized individual traffic)

4.4.2 Traffic safety

4.4.3 Use of economical cars

5. Smart Environment

5.1 Attractivity of natural conditions

5.1.1 Sunshine hours

5.1.2 Green space share

5.2 Pollution

5.2.1 Summer smog (Ozon)

5.2.2 Particulate matter

5.2.3 Fatal chronic lower respiratory diseases per inhabitant

5.3 Environmental protection

5.3.1 Individual efforts on protecting nature

5.3.2 Opinion on nature protection

5.4 Sustainable resource management

5.4.1 Efficient use of water (use per GDP)

5.4.2 Efficient use of electricity (use per GDP)

6. Smart Living

6.1 Cultural facilities

6.1.1 Cinema attendance per inhabitant

6.1.2 Museums visits per inhabitant

6.1.3 Theatre attendance per inhabitant

6.2 Health conditions

6.2.1 Life expectancy

6.2.2 Hospital beds per inhabitant

6.2.3 Doctors per inhabitant

6.2.4 Satisfaction with quality of health system

6.3 Individual safety

6.3.1 Crime rate

6.3.2 Death rate by assault

6.3.3 Satisfaction with personal safety

6.4 Housing quality

6.4.1 Share of housing fulfilling minimal standards

6.4.2 Average living area per inhabitant

6.4.3 Satisfaction with the personal housing situation

6.5 Education facilities

6.5.1 Students per inhabitant

6.5.2 Satisfaction with access to the educational system

6.5.3 Satisfaction with the quality of the educational system

6.6 Touristic attractivity

6.6.1 Importance as tourist location (overnights, sights)

6.6.2 Overnights per year per resident

6.7 Social cohesion

6.7.1 Perception of personal risk of poverty

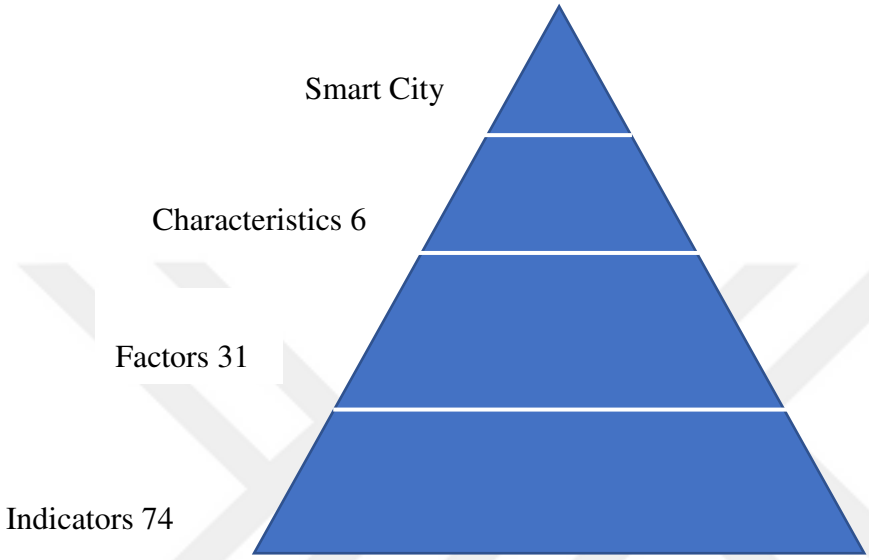

Figure 3.1. *Smart City evaluation hierarchy. Source: (Giffinger, Fertner, Kramar, & Meijers, 2007)*

This evaluation's idea is based on giving the six characteristics of equal weights of 100% for each characteristic.

Each of the factors composing the character is given an equal weight, which results from dividing 100 by the number of factors, e.g., characteristic of Smart Living like Figure 3.2.

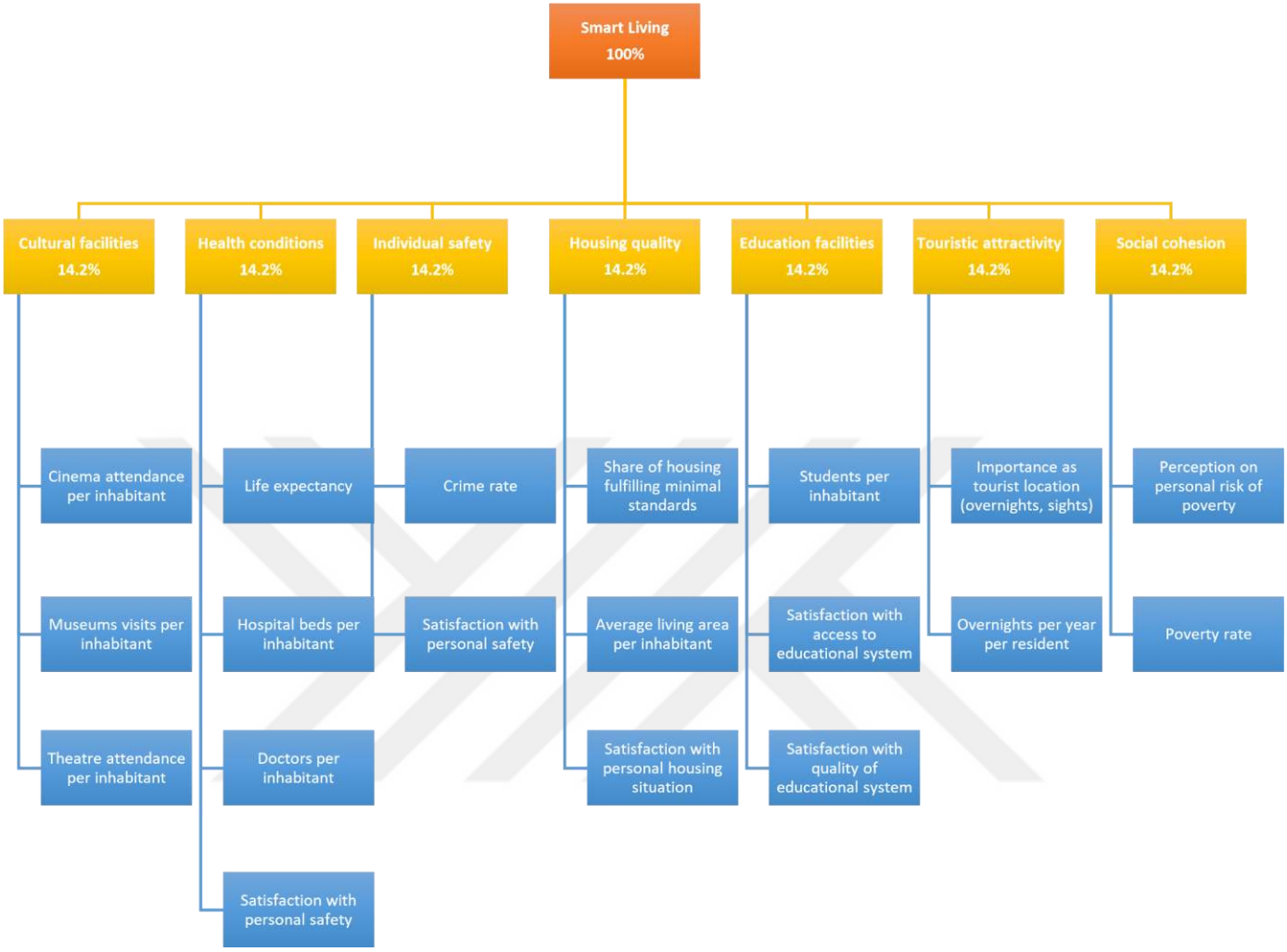

Figure 3.2. *Smart Living hierarchy*

This method relies on the formula shown in Figure 3.3 to standardize the values from the indicators. This formula converts all the indicators'(then factors, characteristics, and whole city) values into standardized values with an average 0 and a standard deviation 1. This formula has the advantage of taking into account heterogeneity in groups and preserves metric information.

$$z_i = \frac{x_i - \bar{x}}{s}$$

Figure 3.3. *Z-Transformation*

In order to obtain the values of factors, characteristics, and final values of the city as a whole, an aggregation process is performed, and the average is taken by adding the values and dividing them by their number, due to the difficulty of accessing some data.

Therefore, all the characteristics are equally important and are given equal representation in the final aggregation process.

3.6 Models Analysis

From the previous Rankings, it becomes clear that proper evaluation should be based on Type 4 in Table 1

- The standards that meet Type 4 are IESE standards and Vienna University of Technology standards.
- We can observe the difference in the objectives of the rankings, so we can consider the aim behind the evaluation of Komninos-Sefertzi is academic, the objective of the evaluation of the Smart Society Forum is a commercial aim, while the aim of the evaluation of the Regional Science Center of the Vienna University of Technology is to identify development priorities to initiate a development plan accordingly.
- The two ranking systems Vienna University of Technology and the IESE, are the most comprehensive of the different rankings.
- Given each ranking system's characteristics, objectives, and methodology, we can confine the competition between the two assessments of the Vienna University of Technology and the IESE.
- The Vienna University of Technology's ranking was based on the evaluation of medium-sized European cities, while the IESE was based on the evaluation of all

cities, including major cities such as London and New York, which ranked first and second respectively.

- The IESE evaluation was applied to 174 different cities worldwide from different continents and different population weights.
- The Vienna University of Technology evaluation was applied to 70 European cities of medium size; having at least one university in each city was mandatory.
- The evaluation of the University of Vienna depends on a transparent methodology more than any other evaluation. This methodology gives detailed results that clarify the city's strengths and weaknesses and thus develop a development plan characterized by clear priorities.
- Since the evaluation of both the University of Vienna and the IESE is considered the best, but the evaluation of the University of Vienna is the most appropriate because it measures the performance of medium-sized cities also studies a harmonious geographic and demographic segment, takes into account the specificity of each city, at the same time adopts a clear methodology in the evaluation.

3.6.1 Conclusion

- Given the nature of the city of Eskişehir close to medium-sized European cities and the previous evaluation forms, the best model for assessing the city of Eskişehir is the evaluation system of the Vienna University of Technology.
- After applying the Vienna University of Technology assessment to 70 mediumsized European cities, Luxembourg ranked first, and the Italian city of Naples was in the last places.
- A comparison will be made between the three cities, Luxembourg from the top and Naples from the bottom, with Eskişehir.
- We will obtain results according to the formula mentioned in Figure 3, after which the aggregation process will take place, meaning that the results of each city will be its result compared to the other two cities, and this means that some factors will have a negative value if the performance in them is low compared to the performance of the same factors in the other two cities.

4. APPLYING THE CHOSEN MODEL

The collaborative model developed by the Center of Regional Science at the Vienna University of Technology, the Department of Geography at the University of Ljubljana, and the OTB Research Institute for Housing, Urban and Mobility Studies at the Delft University of Technology will be implemented.

4.1 Introduction

The population of Eskişehir is about 870 thousand people (Naples 967 thousand and Luxembourg 120 thousand people). It is considered a scientific and cultural city, as it contains three universities: Anadolu University, Eskişehir Technical University, and Osman Gazi University, and many cultural centers.

The performance of Eskişehir will be compared with the cities of Luxembourg and Naples on the level of all six characteristics in the model, and a chart will be made for each of the factors that make up the characteristics, then a chart of the characteristics themselves and finally a chart of the city as a whole.

Before obtaining the chart, the numerical values resulting from applying the Ztransform formula mentioned in Figure 3 must be extracted to access the Z-conversion formula's numbers. We must extract several other numbers, as will be shown in the following table.

In some indicators, the increase in the value is reflected adversely on the evaluation, such as poverty rate, crime rate, pollution indicators, consumption of water, electricity, and others; in this case, the complementing number is adopted in order to maintain the accuracy of the data representation, it is marked with *.

How does It work?

Here is an example to explain how the chosen model works.

Factor	Indicator	Luxembourg	Eskişehir	Naples	Arithmetic Mean	Variation	Standard deviation	(X-Xbar)^2 Lux	(X-Xbar)^ 2 Esk	(X-Xbar)^ 2 Nap	Z-Transformation Lux	Z-Transformation Esk	Z-Transformation Nap
Factor1	Indicator1	Value of Indicator1	Value of Indicator1	Value of Indicator1									
	Indicator2	Value of Indicator2	Value of Indicator2	Value of Indicator2									
	Indicator3	Value of Indicator3	Value of Indicator3	Value of Indicator3									
Aggregation													
Factor2	Indicator1	Value of Indicator1	Value of Indicator1	Value of Indicator1									
	Indicator2	Value of Indicator2	Value of Indicator2	Value of Indicator2									
	Indicator3	Value of Indicator3	Value of Indicator3	Value of Indicator3									
	Indicator4	Value of Indicator4	Value of Indicator4	Value of Indicator4									
Aggregation													

Image 4.1. *Researcher, "Layout of Chosen Model"*

To implement Z-transformation formula

$x_i =$ value of indicator(i)

Arithmetic Mean/Xbar/ $(\bar{x}) = \frac{\sum_{i=1}^{n} x_i}{n}$ $\qquad z_i = \frac{x_i - \bar{x}}{s}$

Variation $(S^2) = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}$

Standard deviation (S) $= \sqrt{S^2}$

Aggregation = Arithmetic Mean of Z-Transformation for each city

For each factor, we enter the actual value of its indicators to obtain the ZTransformation formula; after that, we take the arithmetic mean of the Z-Transformation and put it in the aggregation box for each city. We repeat this process for each factor, and then we take the arithmetic mean of each characteristic by taking the arithmetic mean of all aggregations for each city. Thus, we have obtained the aggregation of the fundamental characteristic.

We repeat this process for each characteristic and then take the arithmetic mean of all the characteristics combined to get the final total.

Because some indicators were not available locally (City), some indicators referred to regional data, some to national.

Local(L)

Region(R)

National(L)

4.2 Smart Living

Factor	Indicator	Luxembourg	Eskişehir	Naples	Arithmetic Mean	Variation	Standard deviation	(X-Xbar)^2 Lux	(X-Xbar)^2 Esk	(X-Xbar)^2 Nap	Z-Transformation Lux	Z-Transformation Esk	Z-Transformation Nap
Cultural facilities	Cinema attendance per inhabitant(L)	11.3	1.2	0.3	4.27	37.30	6.11	49.47	9.40	15.73	1.15	-0.50	-0.65
	Museums visits per inhabitant(L)	1.2	1.05	0.5	0.92	0.14	0.37	0.08	0.02	0.17	0.77	0.36	-1.13
	Theatre attendance per inhabitant(L)	5	0.2	0.2	1.80	7.68	2.77	10.24	2.56	2.56	1.15	-0.58	-0.58
Aggregation		**1.03**	**-0.24**	**-0.79**									
Health conditions	Life expectancy(L)	81	78	80	79.67	2.33	1.53	1.78	2.78	0.11	0.87	-1.09	0.22
	Hospital beds per inhabitant(L)	4.6	4.4	2.5	3.83	1.34	1.16	0.59	0.32	1.78	0.66	0.49	-1.15
	Doctors per inhabitant(L)	2.9	1.3	0.7	1.63	1.29	1.14	1.60	0.11	0.87	1.11	-0.29	-0.82
	Satisfaction with quality of health system(L)	0.79	0.78	0.12	0.56	0.15	0.38	0.05	0.05	0.20	0.59	0.56	-1.15
Aggregation		**0.81**	**-0.08**	**-0.73**									
Individual safety	Crime rate(L)*	93.8	83.79	37.2	71.60	912.40	30.21	492.99	148.68	1183.13	0.74	0.40	-1.14
	Death rate by assault(L)*	9.9	8.4	9.7	9.33	0.66	0.81	0.32	0.87	0.13	0.70	-1.15	0.45
	Satisfaction with personal safety(L)	0.85	0.7	0.5	0.68	0.03	0.18	0.03	0.00	0.03	0.95	0.09	-1.04
Aggregation		**0.79**	**-0.22**	**-0.58**									

Image 4.2. *Researcher, "Smart Living"*

Housing quality	Share of housing fulfilling minimal standards(L)	98	98	97.7	97.90	0.03	0.17	0.01	0.01	0.04	0.58	0.58	-1.15
	Average living area per inhabitant(L)	2.2	1	1.3	1.50	0.39	0.62	0.49	0.25	0.04	1.12	-0.80	-0.32
	Satisfaction with personal housing situation(L)	0.78	0.8	0.8	0.79	0.00	0.01	0.00	0.00	0.00	-1.15	0.58	0.58
Aggregation		**0.18**	**0.12**	**-0.30**									
Education facilities	Students per inhabitant(L)	0.017	0.015	0.012	0.01	0.00	0.00	0.00	0.00	0.00	0.93	0.13	-1.06
	Satisfaction with access to educational system(L)	0.65	0.75	0.52	0.64	0.01	0.12	0.00	0.01	0.01	0.09	0.95	-1.04
	Satisfaction with quality of educational system(L)	0.7	0.5	0.4	0.53	0.02	0.15	0.03	0.00	0.02	1.09	-0.22	-0.87
Aggregation		**0.70**	**0.29**	**-0.99**									
Touristic attractivity	Importance as tourist location (overnights, sights)(L)	0.4	0.1	0.2	0.23	0.02	0.15	0.03	0.02	0.00	1.09	-0.87	-0.22
	Overnights per year per resident(L)	4.8	1.2	3.5	3.17	3.32	1.82	2.67	3.87	0.11	0.90	-1.08	0.18
Aggregation		**0.99**	**-0.98**	**-0.02**									
Social cohesion	Perception on personal risk of poverty(R)*	80	48	47	58.33	352.33	18.77	469.44	106.78	128.44	1.15	-0.55	-0.60
	Poverty rate(R)*	9.3	0.8	0.74	3.61	24.25	4.92	32.34	7.91	8.26	1.15	-0.57	-0.58
Aggregation		**1.15**	**-0.56**	**-0.59**									

Continue Image 4.2. *Researcher, "Smart Living"*

Table 4.1. *Smart Living*

Smart Living	Luxembourg	Eskişehir	Naples
	0.81	-0.24	-0.57

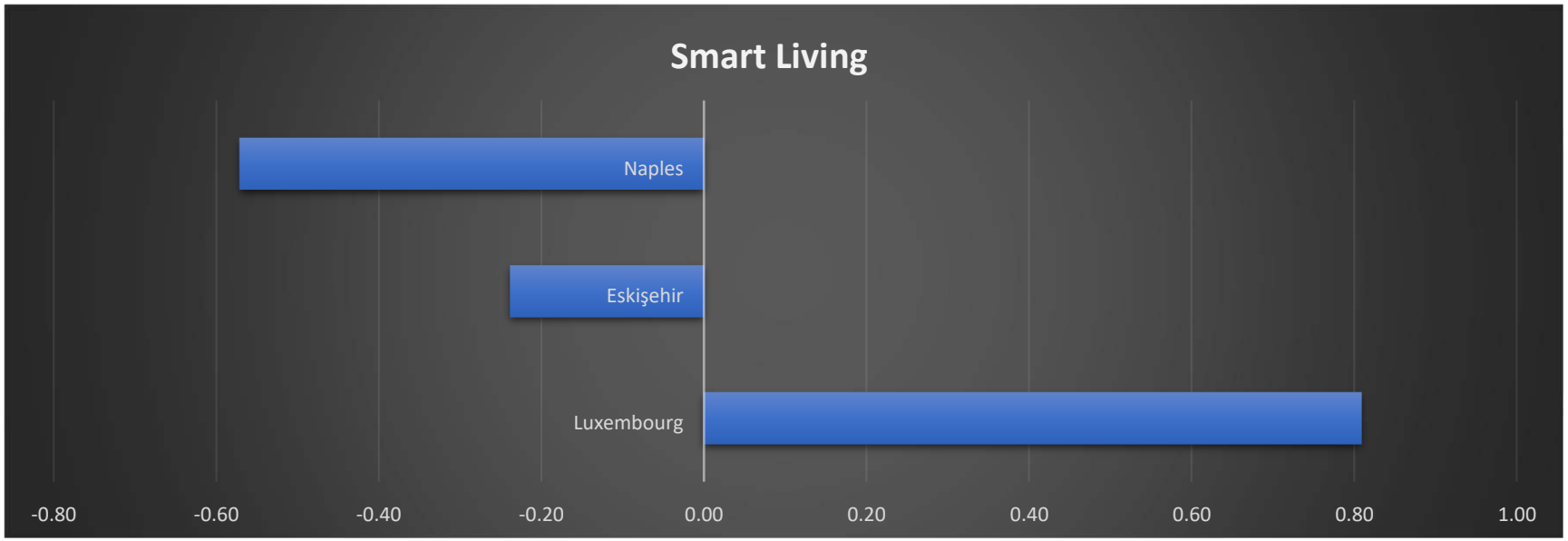

Figure 4.1. *Smart Living*

4.3 Smart Economy

Factor	Indicator	Luxembourg	Eskişehir	Naples	Arithmetic Mean	Variation	Standard deviation	(X-Xbar)^2 Lux	(X-Xbar)^ 2 Esk	(X-Xbar)^ 2 Nap	Z-Transformation Lux	Z-Transformation Esk	Z-Transformation Nap
Innovative spirit	R&D expenditure in % of GDP(R)	1.2	1.06	1.2	1.15	0.01	0.08	0.00	0.01	0.00	0.58	-1.15	0.58
	Employment rate in knowledge-intensive sectors(R)	4.3	0.9	2.6	2.60	2.89	1.70	2.89	2.89	0.00	1.00	-1.00	0.00
	Patent applications per inhabitant(R)	0.0005	0.000004	0.0000019	0.00	0.00	0.00	0.00	0.00	0.00	1.15	-0.57	-0.58
Aggregation		**0.91**	**-0.91**	**-0.0012**									
Entrepreneurship	Self-employment rate(N)	8.5	30.8	22	20.43	126.16	4.52	142.40	107.47	2.45	-2.64	2.29	0.35
	New businesses registered(Per1000)(N)	17.1	1.5	2.9	7.17	74.49	2.68	98.67	32.11	18.20	3.71	-2.12	-1.59
Aggregation		**0.54**	**0.09**	**-0.62**									
Economic image & trademarks	Importance as decision-making centre (HQ etc.)(Approx.)(L)	3	1	2	2.00	1.00	1.41	1.00	1.00	0.00	0.71	-0.71	0.00
Aggregation		**0.71**	**-0.71**	**0.00**									
Productivity	GDP per employed person(1000$)(R)	241	85	98	141.33	7492.33	11.89	9933.44	3173.44	1877.78	8.38	-4.74	-3.65
Aggregation		**8.38**	**-4.74**	**-3.65**									

Image 4.3. *Researcher, "Smart Economy"*

Flexibility of labor market	Unemployment rate(R)*	94	87	80	87.00	49.00	9.33	49.00	0.00	49.00	0.75	0.00	-0.75
	Proportion in part-time employment(R)*	85	90	80	85.00	25.00	9.22	0.00	25.00	25.00	0.00	0.54	-0.54
Aggregation		**0.38**	**0.27**	**-0.65**									
International embeddedness	Companies with HQ in the city quoted on national stock market(L)	8	0	3	3.67	16.33	1.91	18.78	13.44	0.44	2.26	-1.91	-0.35
	Air transport of passengers(per inhabitant)(L)	7.2	0.1	2.1	3.13	13.40	1.77	16.54	9.20	1.07	2.30	-1.71	-0.58
	Air transport of freight(100000tons)(L)	8.21	0.019	0.099	2.78	22.15	1.67	29.53	7.60	7.17	3.26	-1.65	-1.61
Aggregation		**2.61**	**-1.76**	**-0.85**									

Continue Image 4.3. *Researcher, "Smart Economy"*

Table 4.2. *Smart Economy*

Smart Economy	Luxembourg	Eskişehir	Naples
	2.25	**-1.29**	**-0.96**

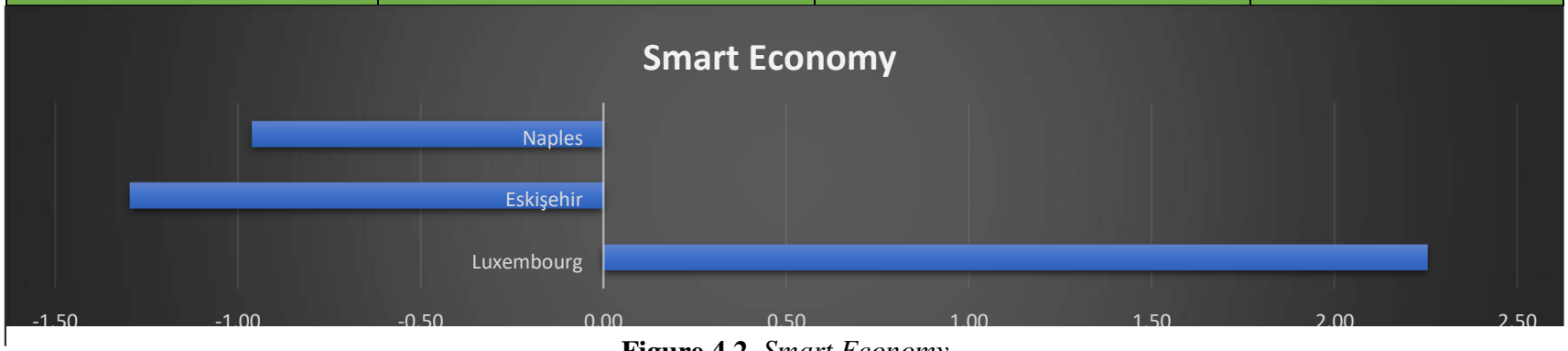

Figure 4.2. *Smart Economy*

4.4 Smart People

Factor	Indicator	Luxembourg	Eskişehir	Naples	Arithmetic Mean	Variation	Standard deviation	(X-Xbar)^2 Lux	(X-Xbar)^ 2 Esk	(X-Xbar)^ 2 Nap	Z-Transformation Lux	Z-Transformation Esk	Z-Transformation Nap
Level of qualification	Importance as knowledge centre (top research centres, top universities etc.)(Approx.)(L)	3	2	1	2.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	-1.00
	Population qualified at levels 5-6 ISCED(L)	41	18.1	12	23.70	233.77	15.29	299.29	31.36	136.89	1.13	-0.37	-0.77
	Foreign language skills(25-64)(N)	85	18	20	41.00	1453.00	38.12	1936.00	529.00	441.00	1.15	-0.60	-0.55
Aggregation		**1.10**	**-0.32**	**-0.77**									
Affinity to life long learning	Book loans per resident(L)	0.14	0.21	0.05	0.13	0.01	0.08	0.00	0.01	0.01	0.08	0.96	-1.04
	Participation in life-long-learning in %(R)	19.1	4.1	5.3	9.50	69.48	8.34	92.16	29.16	17.64	1.15	-0.65	-0.50
	Participation in language courses(N)	3.1	1	1	1.70	1.47	1.21	1.96	0.49	0.49	1.15	-0.58	-0.58
Aggregation		**0.80**	**-0.09**	**-0.71**									
Social and ethnic plurality	Share of foreigners(L)	70.8	1.9	5.9	26.20	1495.87	38.68	1989.16	590.49	412.09	1.15	-0.63	-0.52
	Share of nationals born abroad(N)	32.5	1.4	8	13.97	268.50	16.39	343.48	157.92	35.60	1.13	-0.77	-0.36
Aggregation		1.14	-0.70	-0.44									

Image 4.4. *Researcher, "Smart People"*

Flexibility	Perception of getting a new job(N)	67	44.1	58	56.37	133.10	11.54	113.07	150.47	2.67	0.92	-1.06	0.14
Aggregation		0.92	-1.06	0.14									
Creativity	Share of people working in creative industries(R)	6.1	3.1	2.9	4.03	3.21	1.79	4.27	0.87	1.28	1.15	-0.52	-0.63
Aggregation		1.15	-0.52	-0.63									
Cosmopolitanism / Open-mindednsse	Voters turnout at (European) elections(L)	89.6	89.4	68.2	82.40	151.24	12.30	51.84	49.00	201.64	0.59	0.57	-1.15
	Immigration-friendly environment (attitude towards immigration)(aprox)	85	50	45	60.00	475.00	21.79	625.00	100.00	225.00	1.15	-0.46	-0.69
	Knowledge about the Eu(aprox)	3	1	2	2.00	1.00	1.00	1.00	1.00	0.00	1.00	-1.00	0.00
Aggregation		**0.91**	**-0.30**	**-0.61**									
Participation in public life	Voters turnout at city elections(L)	85	86	54	75.00	331.00	18.19	100.00	121.00	441.00	0.55	0.60	-1.15
	Participation in voluntary work(N)	36	5	12	17.67	264.33	16.26	336.11	160.44	32.11	1.13	-0.78	-0.35
Aggregation		0.84	-0.09	-0.75									

Continue Image 4.4. *Researcher, "Smart People"*

Table 4.3. *Smart People*

Smart People	Luxembourg	Eskişehir	Naples
	0.98	-0.44	-0.54

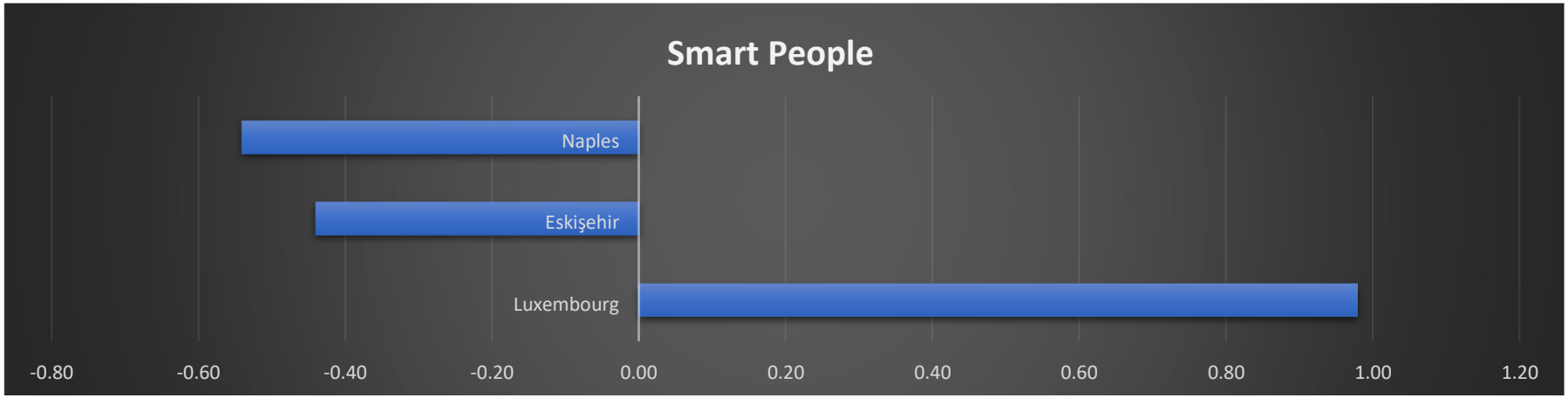

Figure 4.3. *Smart People*

4.5 Smart Governance

Factor	Indicator	Luxembourg	Eskişehir	Naples	Arithmetic Mean	Variation	Standard deviation	(X-Xbar)^2 Lux	(X-Xbar)^ 2 Esk	(X-Xbar)^ 2 Nap	Z-Transformation Lux	Z-Transformation Esk	Z-Transformation Nap
Participation in decision-making	City representatives per resident(per1000)(L)	0.12	0.01	0.02	0.05	0.00	0.06	0.01	0.00	0.00	1.15	-0.63	-0.53
	Political activity of inhabitants(Approx.according to voters turnout) (L)	3.00	2.00	1.00	2.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	-1.00
	Importance of politics for inhabitants(Approx.according to voters turnout) (L)	3.00	2.00	1.00	2.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	-1.00
	Share of female city representatives(L)	30.00	28.50	37.00	31.83	20.58	4.54	3.36	11.11	26.69	-0.40	-0.73	1.14
Aggregation		**1.05**	**-0.21**	**-0.84**									
Public and social services	Expenditure of the municipal per resident in PPS($)(L)	5672.00	106.00	84.90	1954.30	10366081.27	3219.64	13821293.29	3416212.89	3494656.36	1.15	-0.57	-0.58
	Share of children in day care(3-5 years old)(Approx. according to available data(R)	97.00	95.00	95.00	95.67	1.33	1.15	1.78	0.44	0.44	1.15	-0.58	-0.58
	Satisfaction with quality of schools(L)	78.00	57.00	51.00	62.00	201.00	14.18	256.00	25.00	121.00	1.13	-0.35	-0.78
Aggregation		**1.15**	**-0.50**	**-0.64**									

Image 4.5. *Researcher, "Smart Governance"*

Transparent governance	Satisfaction with transparency of bureaucracy(Approx. According to related issues)(L)	3.00	2.00	2.00	2.33	0.33	0.58	0.44	0.11	0.11	1.15	-0.58	-0.58
	Satisfaction with fight against corruption(Approx. According to related issues)(L)	3.00	2.00	1.00	2.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	-1.00
Aggregation		1.08	-0.29	-0.79									

Continue Image 4.5. *Researcher, "Smart Governance "*

Table 4.4. *Smart Governance*

Smart Governance	Luxembourg	Eskişehir	Naples
	1.09	**-0.33**	**-0.76**

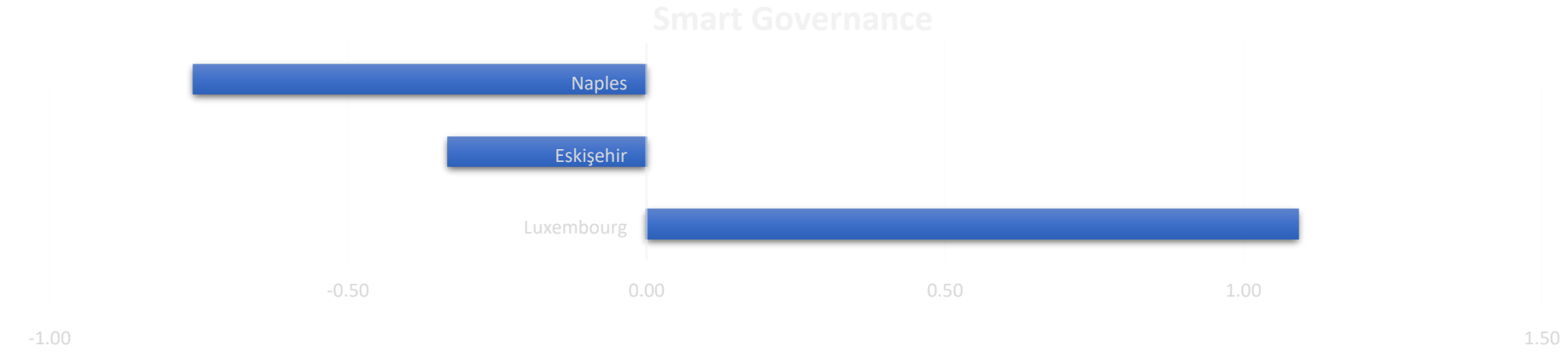

Figure 4.4. *Smart Governance*

4.6 Smart Mobility

Factor	Indicator	Luxembourg	Eskişehir	Naples	Arithmetic Mean	Variation	Standard deviation	(X-Xbar)^2 Lux	(X-Xbar)^ 2 Esk	(X-Xbar)^ 2 Nap	Z-Transformation Lux	Z-Transformation Esk	Z-Transformation Nap
Local accessibility	Public transport network per inhabitant(L)	0.005	0.004	0.0005	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.35	-1.13
	Satisfaction with access to public transport(L)	93	66	45	68.00	579.00	24.06	625.00	4.00	529.00	1.04	-0.08	-0.96
	Satisfaction with quality of public transport(L)	93	66	45	68.00	579.00	24.06	625.00	4.00	529.00	1.04	-0.08	-0.96
Aggregation		**0.95**	**0.06**	**-1.01**									
(Inter-)national accessibility	International accessibility(Approx.According to land, sea and air gates)(L)	9	3.5	7.5	6.67	8.08	2.84	5.44	10.03	0.69	0.82	-1.11	0.29
Aggregation		**0.82**	**-1.11**	**0.29**									
Availability of ICT infrastructure	Computers in households(N)	95	60	70	75.00	325.00	18.03	400.00	225.00	25.00	1.11	-0.83	-0.28
	Broadband internet access in households(R)	95	90	79	88.00	67.00	8.19	49.00	4.00	81.00	0.86	0.24	-1.10
Aggregation		0.98	-0.29	-0.69									

Image 4.6. *Researcher, "Smart Mobility"*

Sustainable, innovative and safe transport systems	Green mobility share (non-motorized individual traffic)(Approx. Acoording to related issues)(L)	2	1	3	2.00	1.00	1.00	0.00	1.00	1.00	0.00	-1.00	1.00
	Traffic safety(R)	0.008	0.0073	0.0075	0.01	0.00	0.00	0.00	0.00	0.00	1.11	-0.83	-0.28
	Use of economical cars(N) (LUX.Approx)	10	5.1	8.6	7.90	6.37	2.52	4.41	7.84	0.49	0.83	-1.11	0.28
Aggregation		0.65	-0.98	0.33									

Continue Image 4.6. *Researcher, "Smart Mobility"*

Table 4.5. *Smart Mobility*

Smart Mobility	Luxembourg	Eskişehir	Naples
	0.85	-0.58	-0.27

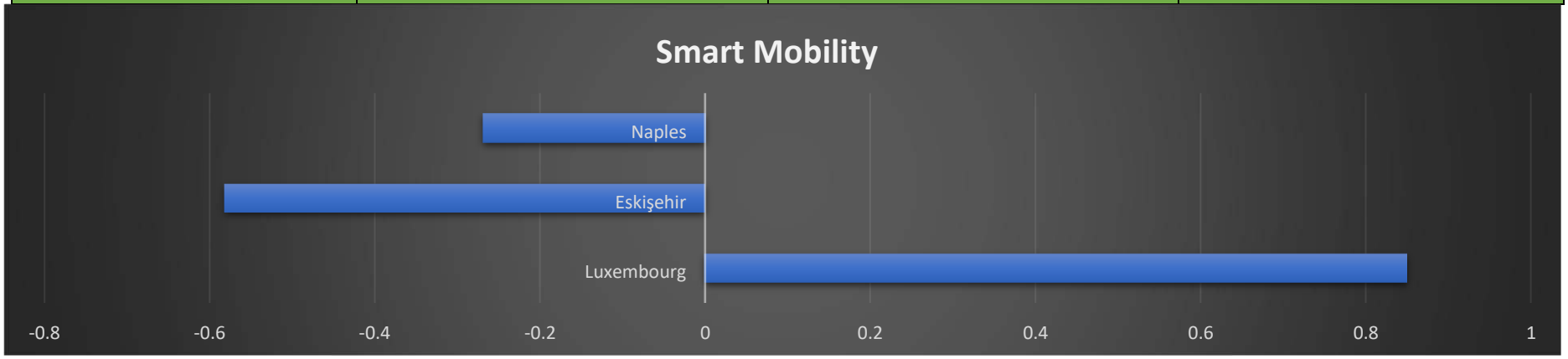

Figure 4.5. *Smart Mobility*

4.7 Smart Environment

Factor	Indicator	Luxembourg	Eskişehir	Naples	Arithmetic Mean	Variation	Standard deviation	(X-Xbar)^2 Lux	(X-Xbar)^ 2 Esk	(X-Xbar)^ 2 Nap	Z-Transformation Lux	Z-Transformation Esk	Z-Transformation Nap
Attractivity of natural conditions	Sunshine hours	1487	2640	2411	2179.33	372604.33	610.41	479325.44	212213.78	53669.44	-1.13	0.75	0.38
	Green space share	25	17	11	17.67	49.33	7.02	53.78	0.44	44.44	1.04	-0.09	-0.95
Aggregation		**-0.05**	**0.33**	**-0.28**									
Pollution	Summer smog (Ozon)(kg per capita)(N)*	75	35	62	57.33	416.33	20.40	312.11	498.78	21.78	0.87	-1.09	0.23
	Particulate matter(L)*	90	74	79	81.00	67.00	8.19	81.00	49.00	4.00	1.10	-0.86	-0.24
	Fatal chronic lower respiratory diseases per inhabitant(N)*	0.04	0.04	0.01	0.03	0.00	0.02	0.00	0.00	0.00	0.58	0.58	-1.15
Aggregation		**0.85**	**-0.46**	**-0.39**									
Environmental protection	Individual efforts on protecting nature(Equal values due to no data)	1	2	3	2	1	1	1	0	1	-1	0	1
	Opinion on nature protection(Equal values due to no data)	3	2	1	2	1	1	1	0	1	1	0	-1
Aggregation		**0**	**0**	**0**									
Sustainable resource management	Efficient use of water (use per GDP)(m3/y)(L)	34.3	57.1	58.4	49.93	183.72	13.55	244.40	51.36	71.68	-1.15	0.53	0.62
	Efficient use of electricity (use per GDP)(MWH)(L)	89.6	97.9	96.6	94.70	19.93	4.46	26.01	10.24	3.61	-1.14	0.72	0.43
Aggregation		**-1.15**	**0.62**	**0.53**									

Image 4.7. *Researcher, "Smart Environment"*

Table 4.6. *Smart Environment*

Smart Environment	Luxembourg	Eskişehir	Naples
	-0.09	0.12	-0.04

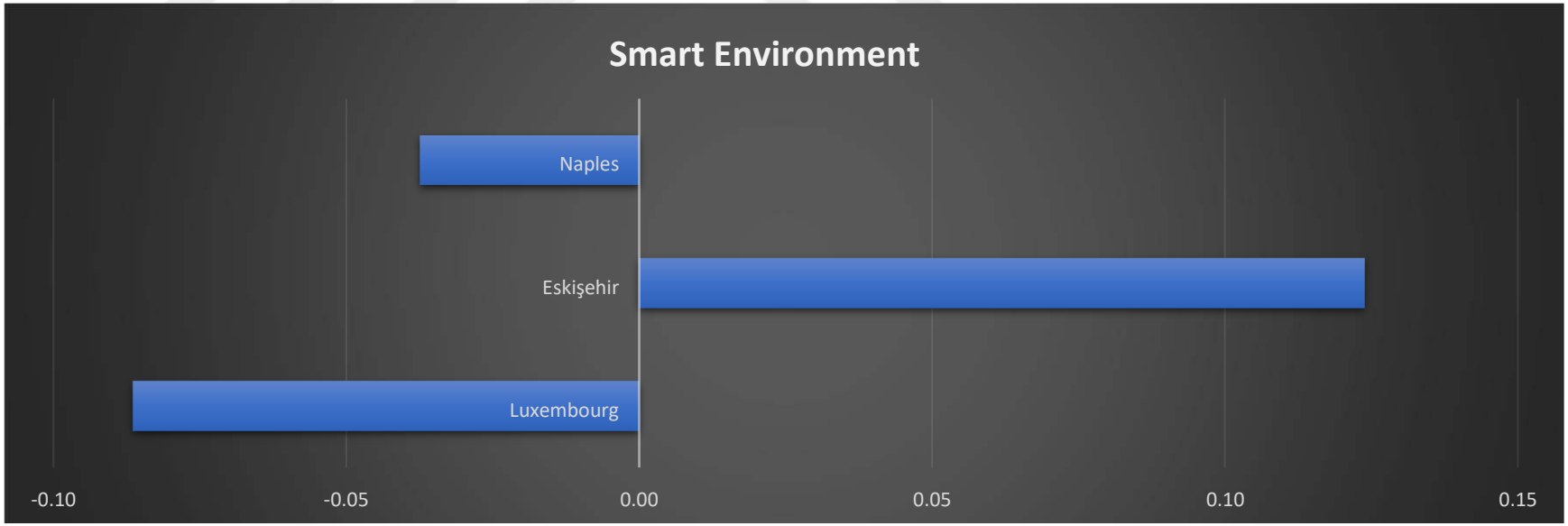

Figure 4.6. *Smart Living*

4.8 Total

Table 4.7. *Total Aggregation*

Smart Living	Luxembourg	Eskişehir	Naples
	0.81	-0.24	-0.57

Smart Economy	Luxembourg	Eskişehir	Naples
	2.25	-1.29	-0.96

Smart People	Luxembourg	Eskişehir	Naples
	0.98	-0.44	-0.54

Smart Governance	Luxembourg	Eskişehir	Naples
	1.09	-0.33	-0.76

Smart Mobility	Luxembourg	Eskişehir	Naples
	0.85	-0.58	-0.27

Smart Environment	Luxembourg	Eskişehir	Naples
	-0.09	0.12	-0.04

Total	Luxembourg	Eskişehir	Naples
	5.97	-2.86	-3.10

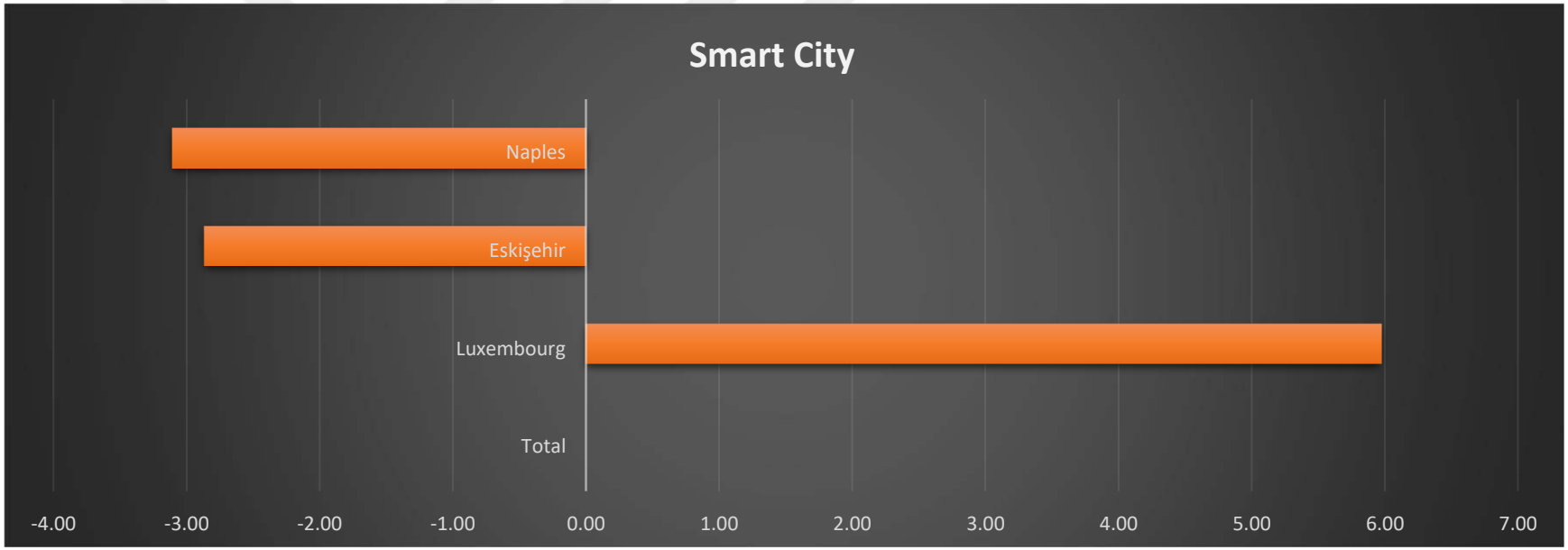

Figure 4.7. *Smart City*

The most important thing here, which must be clarified, is that the negative value of the city **does not mean that the city is not smart or that its performance is terrible. However, the negative value here means that the performance of the city came according to the performance of the city that ranked first**, which is the city of Luxembourg, and this is logical considering that the city of Luxembourg ranked first in all medium-sized European cities.

5. FINDINGS AND RECOMMENDATIONS

1. Smart Living

- This characteristic was divided into seven factors; at the level of cultural facilities, Eskişehir performed well, achieved reasonable numbers, and came second after Luxembourg and ahead of Naples.
- In terms of health conditions, Eskişehir's performance was strong and competitive, but doctors' ratio to citizens needs to be increased.
- Concerning safety inside the city, the city has performed well, but more significant efforts are needed to reduce accidents that lead to murder by raising citizens' awareness.
- Concerning housing quality, Eskişehir's results were close to other cities' results, but the living space for every citizen needs to be increased.
- In terms of educational facilities, Eskişehir's results were strong. Citizens' satisfaction with the quality of the educational system needs to be taken into account.
- Concerning the tourism aspect, the results of Eskişehir were the weakest among the cities, and here it is necessary to pay attention to the need to make more efforts to improve the tourism reality in the city.
- As for poverty rates, the gap was large between Luxembourg and other cities, although this factor bears a national character as being largely convergent within the same country, Eskişehir must make more efforts in this aspect.
- As a final result in this aspect, Eskişehir's results were generally good, outperforming Naples and coming second after Luxembourg.
- The researcher believes that it is imperative to focus on the tourism sector in Eskişehir by strengthening programs to attract tourists and developing tourist facilities, and giving greater importance to promoting the city.

2. Smart Economy

- In this characteristic, Eskişehir recorded the worst numbers compared to other characteristics, and the differences seem clear between Luxembourg that

leading to a big difference, followed by Naples, and in the end comes Eskişehir.

- This result seems logical considering that Luxembourg and Naples are cities of the European Union and Luxembourg being a crucial capital, considering that Naples is a tourist city.
- Although this aspect has a national character and there are no vast differences between cities in a single country, but many things can be worked on to improve.
- This characteristic contains six factors: the worst performance of Eskişehir was in the international embeddedness factor, which is mainly due to the absence of a civilian airport in actual use in the city. The existing airport is used very limitedly for some seasonal flights.

The other factor in which Eskişehir recorded an abysmal performance is the number of companies headquartered in Eskişehir registered in the local stock exchange, as the researcher could not find a single company based in Eskişehir that is registered on the Borsa Istanbul.

- These two factors were important reasons for Eskişehir to obtain a low score in the economic aspect. Therefore, the researcher suggests the necessity of finding a way to operate Eskişehir civil airport, both domestic and international.
- Also, work to encourage companies to open their headquarters in Eskişehir or encourage big companies with a headquarters in Eskişehir to enter the local stock market.

3. Smart People

- This characteristic is divided into seven factors. Eskişehir's overall score was reasonably good and came second after Luxembourg.
- In terms of the degree of educational qualifications, the results were good, except for learning a foreign language.
- The rate of borrowing books in the city is excellent, but participation in lifelong learning programs was weak and needed development. As for the

foreigners ’share, the city’s performance is fragile and needs to be developed in order to give the city a wider dimension.

- The participation rate of residents in local elections was excellent, but their participation in volunteer activities was meager.
- The results show the need to pay attention to the foreign language, which is most likely the English language. The weakness was great here. Therefore, more attention should be paid to this point by organizing regular courses that attract the largest possible number of students and strengthening this point in the curriculum.
- Concerning activities, civil society institutions, governmental and local institutions should also be encouraged to double their activities aim to promote volunteer activity.

4. Smart Governance

- This characteristic is divided into three factors. In general, it can be said that Eskişehir has performed well, but some indicators must be taken care of.
- The percentage of city representatives to the number of the population was the lowest among the cities, so it is possible to work to raise this percentage in coordination with the legal authorities. Also, the share of women’s representation was the lowest among the other cities, although the proportions were not far apart between the three cities, Eskişehir was the last.
- In terms of municipal expenditure per inhabitant, Eskişehir came second among the three cities, and Luxembourg was at the forefront by an extensive margin.
- The percentage of satisfaction with the quality of schools was less than Luxembourg and more than Naples, and therefore it was reasonable, it must be pointed out that the percentage should be developed continuously to improve the quality of the educational process.
- Concerning transparent governance, accurate numbers were not available to measure them, but they were given values that reflect their arrangement according to the researcher's reading of topics related to the same matter.

5. Smart Mobility

- This characteristic is divided into four factors concerned with two main topics are transportation and communication technology.
- Concerning local access in the city, generally, the results were good, as it is surpassed Naples and was close to Luxembourg, but the free transport service in Luxembourg was a decisive factor in raising the rate of satisfaction with the service compared to other cities, so, more efforts can be made to reduce transportation prices in Eskişehir.
- Regarding the external accessibility of the city, Eskişehir's result was the worst among the three cities due to the fact that it does not have a working airport, and therefore the same suggestions regarding the airport that were mentioned previously in the economic section.
- The weak factor was the percentage of vehicles that do not have a motor, such as a bicycle, and Eskişehir ranked last among the three cities. Many initiatives to encourage the use of bicycles in Eskişehir are being implemented, but in order to raise the low rate, more efforts must be made. Also, initiatives to promote economic cars should be encouraged.
- Concerning the infrastructure of information and communication technology (ICT), Eskişehir has scored excellent numbers, mostly this point has a national character for the whole country.

6. Smart Environment

- In this characteristic, Eskişehir achieved its best performance among all other characteristics. Some godly gifts contributed to this, such as the average hours of sunshine.
- Although the total for this aspect was in favor of Eskişehir as it was ahead of the other two cities, the pollution results of Eskişehir were poor.
- More attention should be paid to air quality in Eskişehir, as the pollution rate is the highest among cities. The government and municipality should work

more and adopt tough decisions to find a real solution to the problem of air pollution in Eskişehir.

- Concerning the individual protection of the environment, we could not access information in this regard, so cities were given the same value in this factor.
- Concerning sustainable resource management, Eskişehir's performance was excellent electricity consumption per capita, as the per capita consumption of electricity was the lowest among the three cities. In water rationalization, it came second after Naples. The result was very close.
- For a more efficient consumption of water, awareness campaigns for citizens must be increased to raise awareness in order to achieve a higher rate of efficiency in resource consumption.

6. CONCLUSION AND FUTURE WORK

In this thesis, the concept of a smart city and many similar concepts such as digital city, knowledge city, and sustainable city were discussed, and the differences between them were clarified. It turns out that the concept of a smart city is the broader concept because it is not just limited to the digital, knowledge, or environmental aspect, but rather is integration between many aspects. Whether or not cities are considered smart is a controversial issue, so a clear and organized method had to be used to measure the performance of cities and make comparisons between them. The researcher reviewed many evaluation models to measure cities' performance and then reviewed the advantages and disadvantages of each one. After that, he chose the most appropriate method for measuring the performance of the city of Eskişehir, which is approved by the Vienna University of Technology that aims to measure the performance of medium-sized European cities.

The researcher chose two cities to compare them with Eskişehir, like Luxembourg, which had ranked first among 70 medium-sized European cities, and the Italian city of Naples, which had been ranked late. It is clear from the results that the performance of Eskişehir was acceptable because it came second place after Luxembourg and before Naples, regardless of the negative value produced by the formula adopted in the evaluation. The research clarified that the negative value does not mean that the city is not smart or that its performance was low, but instead reflects the city's evaluation according to the evaluation of the first-placed city, and this varies with the increase in the number of cities.

The most prominent factor that caused the downgrade of Eskişehir was the economic side, as the difference was huge between Luxembourg and Eskişehir. Also, Naples was better than Eskişehir on this side. Through research, the great importance of operating the Eskişehir airport is evident both domestically and internationally. The city’s assessment will see significant improvement in many aspects if this is done. The research highlighted the weaknesses of Eskişehir and suggested solutions to improve performance in order to move up the ranking. In future work, the researcher sees the necessity of adding more cities to the evaluation. The more cities included in the evaluation mean more results. For example, if the evaluation contains ten cities, then the evaluation of Eskişehir can turn positive.

The researcher believes that the indicators in the used model can be developed by adding more indicators concerned with digital transformation to obtain more detailed results for the digital case of cities. Also, it is possible to modify some indicators such as the proportion of computers per capita and to replace them with the proportion of smartphones per capita, or adding indicators to the employment of technological techniques in the health sector, especially after the spread of the Coronavirus pandemic and the fatigue of the medical staff.

In general, it can be said that the used model can be developed. It is also possible to customize the evaluation method to suit Turkish cities; then it is possible to include all Turkish cities for evaluation in order to obtain a straightforward arrangement for Turkish cities and explore the weaknesses in each city then work to fix them.

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CURRICULUM VITAE

Personal Information

Name/Surname	:	Fadi Aljerjawi
Nationality	:	Palestinian
Gender	:	Male

Educational Background

2011-2015	:	Bachelor degree: Information Technology (Multimedia and web

		development department) at Islamic University of Gaza, Palestine
2017-2021	:	MSc Computer Engineering at Anadolu University, Turkey

Work Experience

02/2018-08/2018	:	Graphic Designer, Freelancer
08/2017-06/2018	:	Social media specialist and content writer, Freelancer
07/2019-07/2020	:	Student and Staff Affairs Officer, Al Aqsa International Schools, Istanbul

Language Skills

Arabic	:	Mother Language
Turkish	:	Very Good
English	:	Very Good