VERİMLİLİK DERGİSİ
JOURNAL OF PRODUCTIVITY

RANKING OF 81 PROVINCIAL CENTERS IN TÜRKİYE ACCORDING TO DIGITALIZATION INDEXES

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ABSTRACT

Purpose: The importance of digital Smart City (SC) applications in the productive and effective fulfillment of city services has begun to increase. The aim of this study is calculating the weighted and unweighted urban digitalization indexes (UDI) values and ranking the cities based on these values.

Methodology: Indicators, critical success factors (CSF), and dimensions affecting the digital transformation (DT) of cities were determined through literature review, surveys, and interviews. Urban Digitalization Maps (UDM) were prepared and UDI values were calculated with the help of the areas on these maps. The cities have been ranked according to calculated UDI values. In the research, the relevant indicator values were collected from city institutions to measure CSF rates with city data. In these measurements, the Satyam UDI Calculation technique was used to calculate UDIs, and the Categorical Value Selection technique was used to calculate indicator weight-percentages.

Findings: In the resulting ranking table, it was seen that each province had different UDIs.UDI rankings and UDMs can enable administrators to take the necessary decisions in determining new SC policies and strategies, and thus use city resources more effectively and productively. As a result, since the DT of cities is not only a technological and temporary transformation, but an intergenerational transformation, it has been proposed to digitalize city services according to the Z-Generation.

Originality: This study is the first to measure the level of digital transformation of 81 provinces in Türkiye.

Keywords: Smart Cities, Digital Transformation, Urban Digitalization Index, Urban Digitalization Map, Critical Success Factors.

JEL Codes: C68, C83, Y10.

TÜRKİYE'DEKI 81 İL MERKEZİNİN KENT DİJİTALLEŞME ENDEKSLERİNE GÖRE SIRALANMASI

ÖZET

Amaç: Akıllı Kentler (AK) kent hizmetlerinin verimli ve etkin bir şekilde yerine getirilmesinde önemini giderek artırmaya başlamıştır. Bu çalışmanın amacı, ağırlıklı ve ağırlıksız Kent Dijitalleşme Endeksleri (KDE) değerlerinin hesaplanması ve bu değerlere göre şehirlerin sıralanmasıdır.

Yöntem: Literatür taraması, anketler ve mülakatlar ile kentlerin dijital dönüşümünü etkileyen göstergeler, Kritik Başarı Faktörleri (KBF) ve boyutlar belirlenmiştir. Kent Dijitalleşme Haritaları (KDH) oluşturulmuş ve bu haritalardaki alanlar yardımıyla KDE değerleri hesaplanmıştır. KDE değerlerine göre kentler sıralanmıştır. Araştırmada KBF oranlarının kent verileriyle ölçülebilmesi için ilgili gösterge değerleri kent kurumlarından toplanmıştır. Bu ölçümlerde, KDE'lerin hesaplanmasında Satyam KDE Hesaplama ve ağırlık yüzdelerinin hesaplanmasında Kategorik Değer Seçme tekniği kullanılmıştır.

Bulgular: Oluşan sıralama tablosunda her ilin farklı KDE'lere sahip olduğu görülmüştür. KDE sıralaması ve KDH'lar, yöneticilerin yeni AK politika ve stratejilerinin belirlenmesinde gerekli kararları almalarını dolayısıyla kent kaynaklarını daha etkin ve verimli şekilde kullanmalarını sağlayabilir. Sonuçta kentlerin dijital dönüşümünün sadece teknolojik ve geçici bir dönüşüm olmadığı, nesiller arası bir dönüşüm olduğundan dolayı kent hizmetlerinin Z-Kuşağına göre dijitalleştirilmesi önerilmiştir.

Özgünlük: Bu çalışma Türkiye'de 81 ilin Dijital Dönüşüm seviyesini ölçen ilk araştırmadır.

Anahtar Kelimeler: Akıllı Kentler, Dijital Dönüşüm, Kent Dijitalleşme Endeksi, Kent Dijitalleşme Haritası, Kritik Başarı Faktörleri.

JEL Kodları: C68, C83, Y10.

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DOI: 10.51551/verimlilik.1083057
Research Article | Submitted Date: 04.03.2022 | Accepted Date: 30.05.2022

1. INTRODUCTION

Today, the rapid spread of new Information and Communication Technologies (ICT) transforms the management models and service processes of cities. Therefore, cities, like businesses and universities, have to find ways to their Digital Transformation (DT) by adapting to the digital age. In this respect, DT seems inevitable for the sustainable development of cities, and effective and productive use of urban resources. Digital Transformation of a city means becoming a Smart City (SC) (Satyam, 2017:152). With a short search on the internet, it can be seen that more than a thousand cities in the world carry out SC projects.

Today, providing the Digital Transformation (Digitalization) of the cities has become one of the important problems of the cities to ensure the life, development, and sustainability of the cities, and the effective and productive use of their resources. Because there is a need for digitization of all data, information, and documents produced, used, and analyzed in the city (Kayan, 2019). However, it can be said that the level of digitalization must be determined first to achieve DT, which has become one of the main problems of cities. On the other hand, it is seen that the dimensions, Critical Success Factors (CSF), and indicators used in research measuring the DT level of cities are generally focused on technology and special issues (Vodafone, 2016). Therefore, while measuring the DT of cities, there is a need for more holistic research that measures values in many areas such as economy, education, demographic structure, health, smart city applications, and technical infrastructure. In addition, in the “Smart Cities White Paper” prepared by the Geographical Information Systems (GIS) Directorate, it is stated that individuals and institutions seeking solutions to the needs of cities need some evaluation tools that will show how “Smart” the city is to produce SC solutions. In addition, it is also stated in the bulletin that quantitative and qualitative analysis tools are needed to make these evaluations. The Urban Digitalization Index (UDI) model and Urban Digitalization Maps (UDM) developed in this research can meet the needs of these assessment and analysis tools.

In this research, it has been tried to contribute to the city stakeholders and especially to the city managers by measuring the DT levels of the cities. For this purpose, dimensions, CSFs, and indicators affecting the DT of cities were put into a table through literature review and interviews, and as a result of the evaluation of the indicator data measuring CSFs, it was tried to determine the weighted and unweighted digitization levels of cities. Therefore, the aim of the research is expressed as calculating the weighted and unweighted UDI values of 81 provincial centers in Türkiye after determining and analyzing the CSFs affecting the DT of cities and determining the DT rankings of 81 provincial centers based on this value.

In line with the aim stated here, answers to the following questions were sought in the study:

- What are the dimensions and CSFs that affect the DT of cities and indicators to measure them?
- How are CSF values measured and how is the weighted and unweighted Digitalization Index value calculated for cities?
- How can cities be ranked according to different UDIs?

The discovery of the indicators, CSFs, and dimensions that measure the DT level of cities, and the determination of different UDI rankings with the help of the new UDI calculation model, and trying to help city managers in determining the necessary strategies and policies for the DT and smartening of their cities reveals the importance of this research. Here, the concept of “Digital Transformation Strategy” refers to the answers given to the questions of what, when, where, how, why, and by whom DT will be carried out.

In the research, both explanatory and exploratory research methods were used in line with the question, problem, and purpose determined for the research since the dimensions, CSFs, and indicators affecting the DT level of the cities will be explained and the Digitization Indexes of the cities will be tried to be discovered. For example, with the help of the UDI Computation Model developed for the research, it has been tried to explain how the cities will be ranked and how the DT status of the cities will be visualized with the UDM.

The target audience of this research is city and municipality administrators, the public, companies providing infrastructure services, companies offering SC applications, and local and central public institutions. Therefore, the analysis unit of this research is cities.

The research was divided into introduction, literature review, methodolgy, results, discussion and conclusion sections and reported. In the introduction, the research is summarized in general terms. In the literature review section of the research, index studies on SC and DT of Cities in the world and in Türkiye, and the dimensions and CSFs used in this research are summarized with the help of tables. In the methodology section, the Satyam and Categorical Value Selection techniques, and their formulas used in the calculation of UDIs are introduced. In the results section, the processes and findings of the research

conducted in 81 city centers are reported in detail with the help of Ankara province data. In this result section, the weighted and unweighted UDI values of the provinces were calculated and the weighted and unweighted UDI rankings of the cities were made based on these values. Then, in the discussion and conclusion section, the results of the research were interpreted in the context of 81 provincial centres. In this section, the importance of the research for city administrators and how they can be used are discussed, it is also explained why the research cannot be compared with another research, then the research limitations and assumptions are put forward, and finally the results and suggestions are presented.

2. LITERATURE REVIEW

It can be said that the basis of all changes in the world is the increase in the amount of population and data (Herzberg, 2017: 20). Because of these two fundamental changes, it is inevitable for countries, societies, cities, businesses, and people to change. Almost all of the changes in the last two centuries have occurred in cities. Therefore, cities are undergoing rapid change due to population growth, human behavior, and especially digital technological changes. Digitalization is the basis of these changes. As a result of the DT of cities, the concept of Smart Cities has emerged today. SC, on the other hand, brings new problems as well as new opportunities for people. It is essential to use new methods, processes, systems, and tools for solving problems or seizing opportunities in cities.

Many organizations and research groups in the world make classifications such as the most livable city, the best global city, the smartest city, the most digital city, and the city to find the best job. Recently, various indexes related to the digitization and smartness levels of cities in the World and Türkiye have been developed by different national and international institutions. Because numerical indicators related to the digitalization of cities become extremely important for the design of international and national policies (TÜBİSAD, 2020: 19). These City Index rankings are generally used by cities to increase their promotion and improve their position in the competition between cities (SCRanking, 2007). In the world, PAS 181, ISO 37120, and ISO 37122 determine international standards in the field of Smart Cities.

In the SC indexation studies in the world, many factors have been revealed that affect the smartening or digitalization of cities. In line with these factors, there are many SC Indexes or different evaluation models that make rankings about Smart Cities and digitalization in the world. Some of these are listed in Table 1 and the dimension, CSF, and indicator numbers used in these indexes are given. The studies on SC in Türkiye between the years 2015 and 2019 are listed in Table 2. The studies listed in Table 2 show that there is a need for more holistic research that will measure the Digital Transformation of cities in Türkiye.

As can be seen from Table 1 and Table 2, many dimensions, CSFs, and indicators, whose details are not given in this research, have been defined to create these city indexes. Calculation methods such as Z-Score, Euclidean Distance, and DP2 were used to evaluate the results of these index researches. In this study, a new evaluation technique called "Digitalization Rate" has been proposed as an alternative to these methods.

On the other hand, Smart Economy, Smart Management, Smart People, Smart Life, Smart Mobility and Smart Environment dimensions in the SC Wheel determined in (Cohen, 2012) are used in many UDI calculations listed in the tables. It is seen in the relevant sources that the Smart City CSF values are calculated with different numbers of indicators. The details of these methods can be viewed from the relevant sources.

In line with the literature review and the interviews conducted in Zonguldak districts for this research, the DT dimensions, the CSFs, and the indicators of the cities that will enable them to be measured were determined and listed in Table 3. 61 of the 88 indicators used in the research came from the literature review and 27 of them were proposed in the field interviews with the city stakeholders (chamber of industry and trade managers, municipality information system managers, Türk Telekom managers, etc.).

Table 1. Smart city index studies used in the world

Index Name	*Year*	*Number of Dimensions*	*Number of CSFs*	*Number of Indicators*	*Calculation Method and Explanation*
Boyd Cohen Smart City Index	2012	6	18	66	Z-Score. It affects all other index work
Cisco Global Digital Readiness Index	2018	0	7	28	Z-Score
European Union - Smart City Ranking Model for European Medium-Sized Cities	2007	6	74		Z-Score. It is evaluated over CSFs
IBM Smart City Assessment Model	2016	4	7	28	
European Digital City Index (EDCi)	2016	0	10	41	Euclidean Distance. It is evaluated over CSFs
IESE Cities in Motion	2017	10	0	68	DP2 technique. It is evaluated over weighted dimensions
WSP Global Cities Index	2018	5	6		It is evaluated over CSFs
Satyam SC Index	2017	0	12	60	It recommends calculating CSFs over percentage values
Ahvenniemi SC Index	2017	4	10		
Mapping Smart Cities	2014	3	10	88	Euclidean Distance
SC Diamond Model	2015	8	21		
IMD Smart City Index	2020	2	5	39	It is repeated every year
ISO 37122:2019: Sustainable cities and communities -Indicators for smart cities	2019	0	22	81	Indicator details can be accessed from the relevant source

Source: Nick and Pongrácz (2016)

Table 2. Smart city index studies in Türkiye

Index Name	*Year*	*Number of Dimensions*	*Number of CSFs*	*Number of Indicators*	*Calculation Method and Explanation*
IMM: Istanbul Smart City Index	2017			100	Details could not be found. It is stated that 100 global indicators are used
Vodafone-Deloitte: Smart Cities Roadmap	2016	6	4		CSFs were evaluated based on their digitization percentage values
Ministry of Environment and Urbanization-Smart Cities and Geographical Technologies Department: Smart City Maturity Assessment Model	2019	17	129	497	Information on how it was evaluated was not available
Turkish Informatics Foundation: Türkiye Smart Cities Evaluation Report	2016		14		It is evaluated over CSFs
Aihemaiti Türkiye Smart Cities Ranking Model	2018	0	23	66	Z-Score. Virtual data is used

Source: Çoruh (2021)

Table 3. Dimensions, CSFs, and indicators affecting the digital transformation of cities

Dimensions	*Dimension References*	*CSFs*	*CSF References*	*Number of Indicators*
Smart Technology	Kamrysi et al. (2014), Ahvenniemi et al. (2017), Cisco (2018)	Technology Infrastructure	Cohen (2015), EDCi (2016), Ahvenniemi et al. (2017), Cisco (2018)	13
		Technology Adoption	Cisco (2018)	9
Smart Human	SCRanking (2007), Kamrysi et al. (2014), Cohen (2015), IBM (2016)	Human Capital	EDCi (2016), Ahvenniemi et al. (2017), Satyam (2017), Cisco (2018),	10
		Meeting Human Needs	Satyam (2017), Cisco (2018)	10
Smart Governance	SCRanking (2007), Cohen (2015), IBM (2016), Ahvenniemi et al. (2017), Satyam (2017)	Municipal Governance	SCRanking (2007), Cohen (2015), Ahvenniemi et al. (2017), Satyam (2017), TürkTelekom (2018) , Berger (2019)	11
		Smart City Applications		11
Smart Economy	SCRanking (2007), Cohen (2015), IBM (2016), Ahvenniemi et al. (2017)	Ease of Doing Business	EDCi (2016), Cisco (2018)	8
		Environment of Innovation	Cisco (2018)	9
		Digital Market	EDCi (2016)	7

Source: Çoruh (2021)

3. METHODOLOGY

In this research, first of all, dimensions, CSFs, and indicators that will contribute to the digitalization of cities have been tried to be revealed and their measurement methods have been determined. In addition, in the research, instead of putting forward a new theory about Digital Transformation and testing them with hypothesis testing, a new UDI calculation method was tried to be developed that shows how to measure the DT level of cities and how to rank them. The spreadsheet program was used in the data processing process such as recording, processing, visualizing, and analyzing the data used in the research. The calculation details of these tables are explained in the Results section. The research model shown in Figure 1 was used throughout the research.

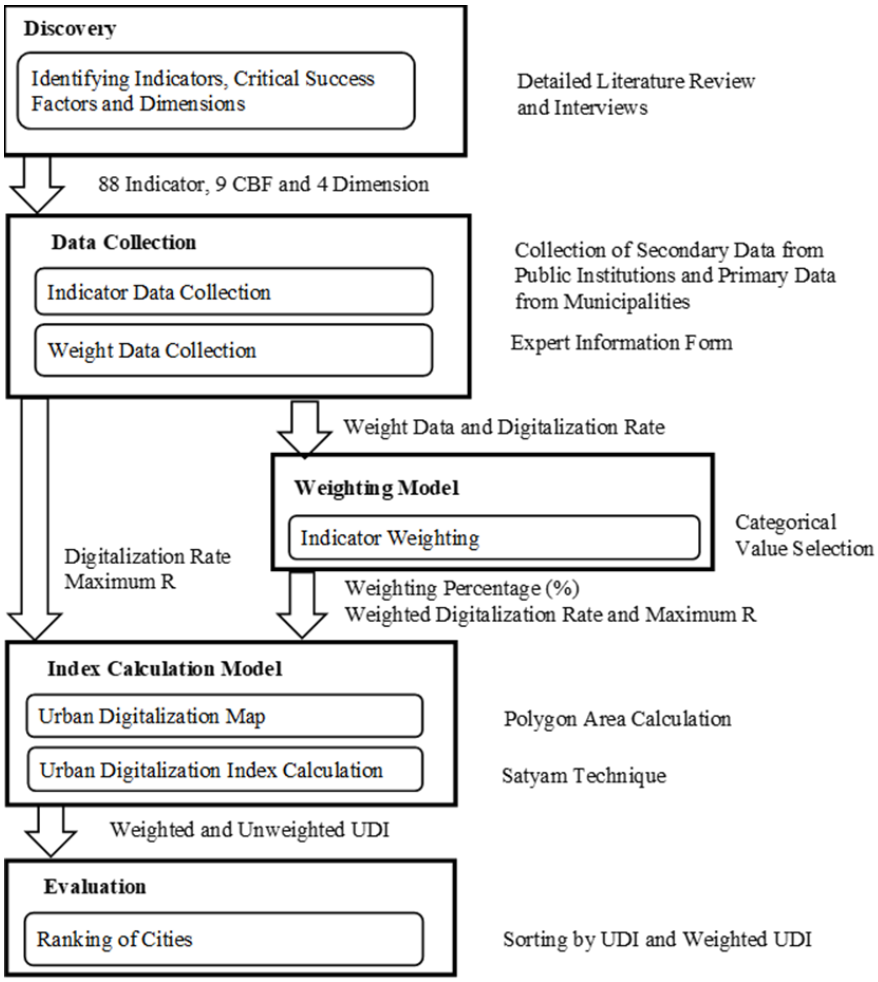

Figure 1. Research model (Çoruh, 2021)

As can be seen from the model in the figure, the necessary indicators, CSFs, and dimensions for measuring the digitization level of cities or determining the Urban Digitalization Index were discovered with the help of literature review and interviews at the Discovery stage. Then, indicator and weighting data were collected from primary and secondary sources at the "Data Collection" stage, and weighted and unweighted Digitalization Rates and Maximum R values were calculated with the help of the formulas determined in this research. In these calculations, Türkiye's average data were obtained from the official websites (secondary sources) of institutions such as TUIK (2019a, 2020, 2020a), BTK (2019), TOBB (2019), TUBISAD (2019), TIM (2019), SGK (2019), YOK (2019), ATGM (2020, 2020a, 2020b), BTGM (2019), CI (2020), Egitim-Sen (2018), Invest (2019), KOBITEK (2014), Nick.tr (2019), SBB (2019), SGB (2019), HaberTurk (2019), and TurkPatent (2019). It has been observed that these secondary source data, published on an annual and monthly basis, are generally published based on Türkiye and provinces (Çoruh and Cebeci, 2020). The primary municipal data required for the research were collected from the IT departments of the provincial central municipalities with the help of Information Forms. Indicator weights were calculated by using the Categorical Value Selection technique of the survey data collected with the help of the Expert Information Forms sent to the IT departments.

In the Index Calculation Model stage, the weighted and unweighted UDI values of the cities were calculated by using the Polygonal Area Calculation and Satyam Technique. In addition, at this stage, weighted and unweighted UDMs that can be used by city managers in making decisions about the city were created by visualizing the weighted and unweighted Digitalization Rate values calculated based on CSF with the help of indicator values. In the Evaluation stage, different rankings of the cities were determined according to their weighted and unweighted UDI values.

To calculate the Digitalization Rates specified in the model, the weighted and unweighted indicator ratio value totals were found for each CSF by proportioning the indicator data with the calculated Türkiye average data. Then, these totals were divided by the number of indicators of each CSF and weighted and unweighted CSF ratios were found. With these Digitalization Ratio values, the areas (nonagonal areas) of

the UDM were created. These area values were also calculated with the area calculation method explained in Satyam (2017: 177).

In the calculation of the smart (digitalization) area, it is necessary to calculate the total areas of the triangles. Therefore, the total area of the triangles in Figure 2 can be calculated with the following formula (Satyam, 2017: 177):

$$Smart\ Area = \sum_{x=1}^{N} \frac{(A*B*Sin\ 40)}{2} \quad (1)$$

N: Number of CSF,

A: Ratio Value of 1st CSF forming the triangle,

B: Ratio Value of the 2nd CSF forming the triangle,

Sin 40: It represents the angle between two Length values (40 degrees is coming from 360/9-CSFs).

The Urban Digitization Index is also calculated with the following formula (Satyam, 2017: 177):

$$UDI = \frac{\text{Smart Area}}{\pi * R^2} * 100 \quad (2)$$

The UDM model used in these calculations is shown in Figure 2, and the CSFs are listed in Table 3 in the previous section. It is assumed that each city center in the research has the indicator values of the CSFs listed in the table and these indicator values and their scope distinguish the Smartness or Digital Transformation level of a city from the others (Satyam, 2017: 175).

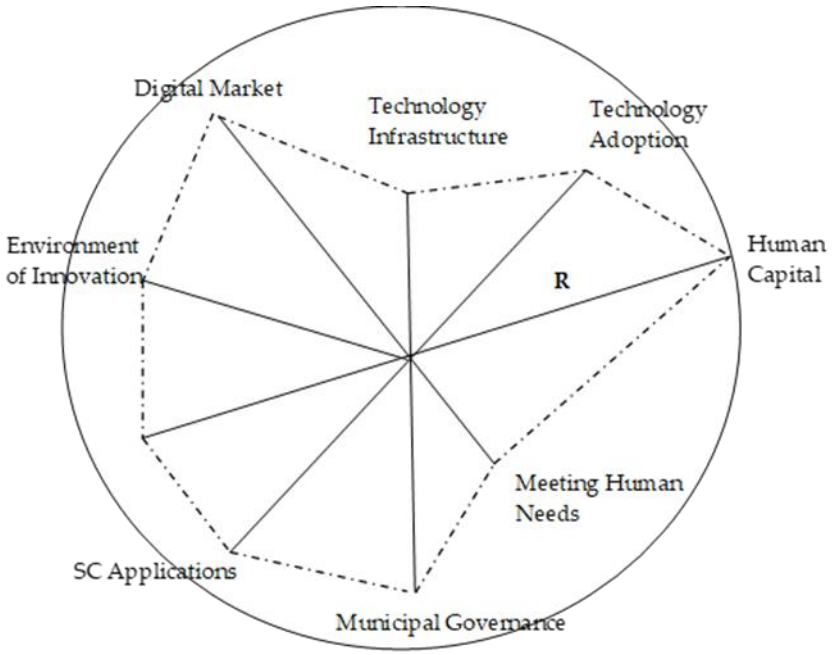

Figure 2. Smart City Urban Digitalization Map (Satyam, 2017)

It is accepted that the city with the higher area value in Figure 2 is the more digital city. The value obtained by dividing this nonagonal area by the circle area containing this nonagonal area was accepted as UDI. In this calculation, which is called the Satyam UDI Calculation technique in the research, the largest circle radius (R) determined from the data of 81 provinces was used.

As a result, all provinces are ranked with the calculated weighted and unweighted UDI values. These UDI and ranking values can be used by city managers to determine the level of digitalization of their cities and, depending on this value, to develop strategies and policies that will ensure urban competitiveness and smartness (Satyam, 2017: 177). A form was prepared in Excel to collect the data values of the indicators under the Satyam UDI calculation method on a provincial basis. The form was sent to the provincial center municipalities and the questions were asked to be answered. This data collection process, which started on June 25, was completed on November 11, 2020, by receiving answers from 81 provincial centers.

After the indicator data were collected, the indicator weights of the research were determined in line with the expert opinions. Two e-mails were sent to the IT departments of all municipalities to answer the survey questionnaire, with an interval of 15 days. IT Expert Surveys were completed until 31 October 2020.

In this research, the UDI was tried to be prepared with a more holistic approach by collecting data about the city not only from municipalities but also from many institutions such as BTK, TOBB (2019), SGK (2019), TİM (2019), TUBISAT, TSO, MEB, YÖK. For this, 88 indicators including economic, technological, social, demographic, local governance, and legal elements that affect the Digital Transformation of cities were used.

4. RESULTS

In this section, how the UDI calculation process is done based on provinces was explained using Ankara province data. For this purpose, Ankara Province Technology Infrastructure (CSF_1) calculations, which consist of 13 indicators, are shown in Table 4.

The averages for Türkiye in the table are calculated with data collected from secondary sources. For example, to find the Türkiye average of "Fixed telephone subscribers per thousand inhabitants", which is the first indicator in the table, the Fixed Telephone Subscribers (11,284,652) in Türkiye in the BTK Secondary data source (dated 31.12.2019) are multiplied by 1000 and divided by the population of the country (83,154,997) and 136 (approximately) was found. All these calculations are listed in the column of "Türkiye Avg.". The data came from the field (from Türk Telekom) is 1,082,825 for fixed telephones. The required data should be (5 639 076 * 136) / 1000 = 765 258 (Excel result) according to the population of Ankara province. Ratio (a/b) column in Table 4: It gives the ratio value of 1,082,825 / 765,258 = 1.41 (approximately). The ratio values of 13 indicators for CSF_1 were calculated one by one in this way.

Table 4. Calculation of Ankara province technology infrastructure (CSF_1) ratio (a/b) value

Indicators and Scope Description	*Türkiye Avg.*	*Ratio Type*	*Collected (a)*	*Required (b)*	*Ratio (a/b)*
Number of fixed telephone subscribers per 1000 people in the city	136	Flat	1,082,825	765,258	1.41
Number of fixed broadband (Fiber, xDSL, Cable, Other) internet subscribers per 1000 inhabitants in the city	171	Flat	1,317,161	965,128	1.36
Number of mobile (3G/4G/5G) internet subscribers per 1000 people in the city	750	Flat	4,489,023	4,232,119	1.06
ADSL average download/upload speed in the city (MB/Sec.)	24.28	Flat	24	24	1.00
Average monthly broadband internet price in the city (₺/Month)	79 ₺	Reverse	79 ₺	79 ₺	1.00
Number of mobile phone subscribers per 1000 people in the city	972	Flat	6,098,759	5,478,755	1.11
Mobile internet (3G/4G/5G) broadband speed (MB/Sec.) in the city	31.57	Flat	32	32	1.00
Average monthly mobile phone cost in the city (₺/Month)	35 ₺	Reverse	35 ₺	35 ₺	1.00
Number of free public Wi-Fi Hotspots per 10 Km2 in the city	10	Flat	20	3,991	0.01
Is there a Wireless Municipal Internet Network (WMIN) in the city? (Y=1/N=0)	1	Flat	0	1	0.00
Is there a Wi-Fi 6.0 Infrastructure for the Internet of Things sensor (water, electricity, gas meter) in the city? (Y=1/N=0)	1	Flat	0	1	0.00
Number of Cable TV subscribers per 1000 people in the city	15	Flat	200,264	86,730	2.31
Number of CCTV security cameras per 10 km2 in the city	10	Flat	80	3,991	0.02
Total					11.29

By summing the Ratio results of 13 indicators, the CSF_1 total value was found as 11.29. After the same operations are done for the other 8 CSFs, the results are shown in the Collected (a) column in Table5.

Then Digitalization Ratio (a/b) was found by dividing these measured values by Required (b) values. These calculated Digitalization Ratios are visualized as UDM in Figure 3. The area shown with red lines in Figure 3 shows the average Digitization ratio values of 81 provinces. It is seen from the figure that the Digitalization Ratio values of Ankara province are above the Türkiye average, excluding Municipal Governance.

Table 5. Ankara province digital transformation CSF digitalization ratio (a/b) values

Dimensions	*CSFs*	*Measured (a)*	*Required (b)*	*Digit. Ratio (a/b)*	*Weighted (%) (c)*	*Weighted Ratio (a/b*c)*
Smart Technology	Technology Infrastructure	11.29	13	0.868	17.98	0.156
	Technology Adoption	8.00	9	0.889	12.04	0.107
Smart Human	Human Capital	11.25	10	1.125	11.19	0.126
	Meeting Human Needs	6.75	10	0.675	9.50	0.064
Smart Governance	Municipal Governance	5.17	11	0.470	16.17	0.076
	Smart City Applications	5.00	11	0.455	10.80	0.049
Smart Economy	Ease of Doing Business	6.27	8	0.784	6.05	0.047
	Environment of Innovation	11.85	9	1.317	8.37	0.110
	Digital Market	3.21	7	0.459	7.91	0.036
Total		68.79	88	0.782	100.00	0.772
Average		7.64	10	0.782	11.11	0.086
Maximum (R)				1.317		0.156

The Weighted Digitalization Rate values in Table 5 for Ankara province were found by multiplying the Digitalization Ratio (a/b) values with the indicator Weight (%) (c). The weight (%) value was obtained by calculating the results of the Survey using the Categorical Value Selection (details not given in this research) technique. Based on the Weighted Ratio (a/b*c) values in Table 5, the Ankara province Weighted Urban Digitalization Map is shown in Figure 4.

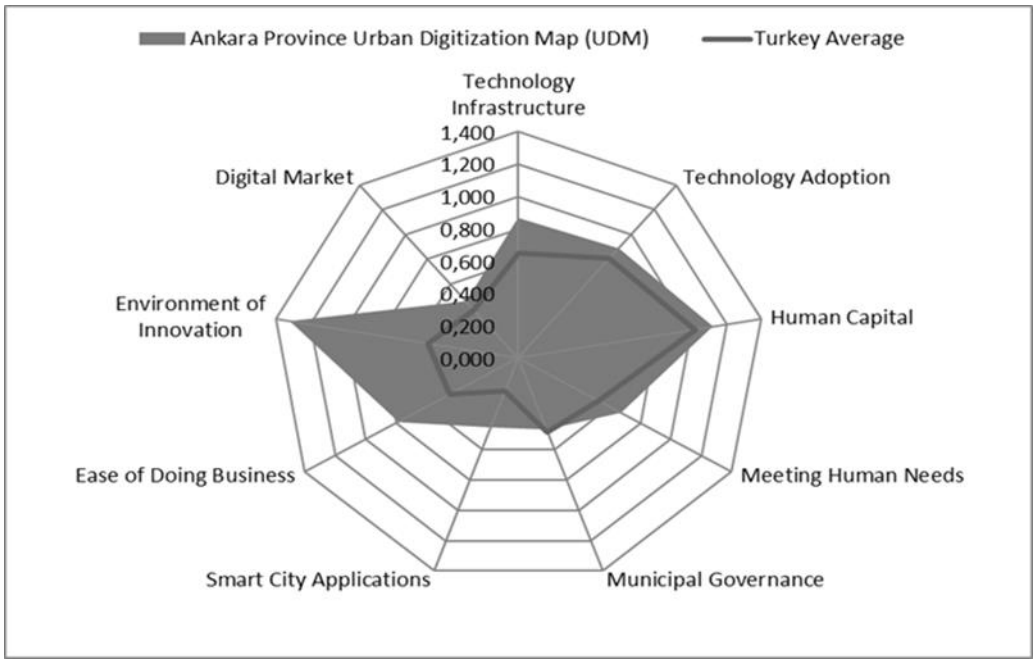

Figure 3. Ankara province urban digitalization map (UDM)

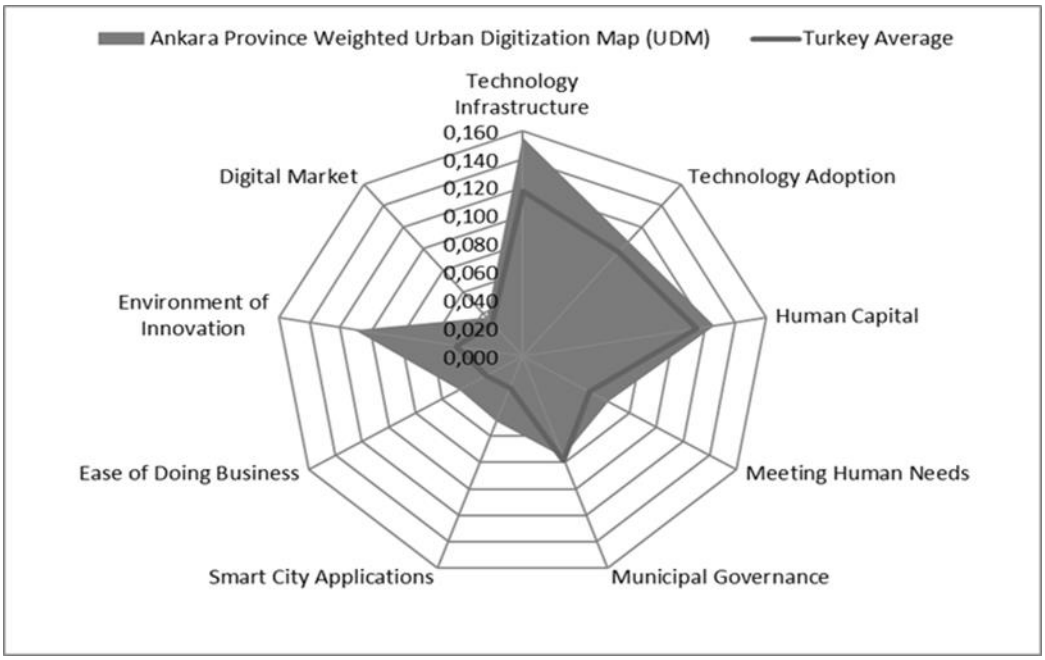

Figure 4. Ankara Province Weighted Urban Digitalization Map (UDM)

The R-value used in the calculation of UDI values was calculated according to the maximum R-value of all provinces. UDIs have been calculated by dividing the triangular area sums of the cities by the area of the circle produced from this maximum R. Later, these UDI values have been used to rank all the provinces. For example, when calculating the UDI of Ankara and all other provinces, instead of Ankara's maximum R-value of 1,317, the ratio value of 1.414 from Karabük was used. With the UDMs in Figure 3 and Figure 4 and the help of Satyam UDI calculation formulas, Ankara's UDI=0.323 and Weighted UDI=0.197 were calculated.

This calculation process described for Ankara was calculated separately for 81 provinces with the help of an Excel table, and weighted and unweighted UDIs were calculated and listed in Table 6. At the end of these processes, the Digitization Ratio (a/b), UDI, and Weighted UDI have been calculated. However, the sorting in the table is based on the UDI column. In the last column of the table, whether a Smart City project in the relevant provincial Municipality is given as information. As can be seen in the bottom line of the table, it has been reported by the municipalities that 43 of the 81 provinces have SC projects.

As can be seen from the Weighted UDI ranking calculated according to the indicator weights of the provinces based on CSF, the weighted ranking is different. When it is looked at the rankings made according to the weighted and unweighted UDI values in the table, it can be said that the formation of different rankings, the calculation of the UDI values by weighting the indicators with the help of the experts, and the ranking according to this means has a value or statistically significant for the city municipality administrators.

Table 6. Ranking of provinces by weighted and unweighted urban digitalization indexes

UDI Ranking	*Weighted UDI Ranking*	*Province*	*Digitalization Ratio*	*UDI*	*Weighted UDI*	*Is there a SC-Project?*
1	1	Istanbul	0.827	0.363	0.229	1
2	3	Kocaeli	0.821	0.346	0.219	1
3	2	Konya	0.804	0.330	0.228	1
4	5	Ankara	0.782	0.323	0.197	1
5	6	Izmir	0.747	0.287	0.195	1
6	4	Erzurum	0.723	0.282	0.200	1
7	7	Isparta	0.675	0.265	0.183	1
8	8	Denizli	0.714	0.264	0.182	1
9	9	Sakarya	0.682	0.247	0.160	1
10	13	Eskişehir	0.685	0.240	0.158	1
11	18	Tekirdağ	0.660	0.235	0.152	1
12	11	K. Maraş	0.659	0.232	0.159	1
13	24	Manisa	0.618	0.229	0.143	0
14	16	Karabük	0.607	0.225	0.154	0
15	22	Düzce	0.640	0.225	0.145	0
16	14	Balıkesir	0.649	0.222	0.157	1
17	15	Mersin	0.637	0.222	0.156	1
18	10	Muğla	0.641	0.221	0.160	1
19	12	Antalya	0.658	0.221	0.158	1
20	19	Adana	0.645	0.219	0.151	1
21	20	Kayseri	0.652	0.218	0.148	1
22	21	Bolu	0.623	0.214	0.147	1
23	23	Kütahya	0.631	0.211	0.144	1
24	17	Bursa	0.649	0.206	0.152	1
25	27	Karaman	0.605	0.201	0.141	1
26	28	Çanakkale	0.589	0.201	0.138	1
27	25	Kırşehir	0.588	0.200	0.142	1
28	29	Burdur	0.573	0.199	0.137	0
29	34	Bilecik	0.591	0.197	0.132	0
30	26	Artvin	0.573	0.195	0.142	1
31	30	Niğde	0.581	0.195	0.135	1
32	33	Yalova	0.592	0.192	0.133	0
33	31	Şanlıurfa	0.589	0.191	0.134	1
34	35	Sivas	0.593	0.189	0.132	1
35	36	Elâzığ	0.591	0.186	0.131	1
36	32	Edirne	0.563	0.185	0.134	0
37	45	Gaziantep	0.574	0.184	0.122	0
38	42	Aydın	0.571	0.183	0.123	1
39	41	Rize	0.559	0.182	0.125	1
40	37	Ordu	0.576	0.181	0.130	1
41	39	Nevşehir	0.562	0.181	0.127	0
42	40	Trabzon	0.566	0.180	0.126	1
43	44	Malatya	0.578	0.178	0.123	1
44	38	Zonguldak	0.578	0.176	0.128	0
45	46	Çorum	0.565	0.173	0.122	0
46	47	Samsun	0.564	0.170	0.120	1
47	43	Erzincan	0.560	0.170	0.123	0
48	49	Afyonkarahisar	0.544	0.169	0.115	0
49	51	Kırklareli	0.547	0.167	0.114	0
50	54	Giresun	0.530	0.165	0.114	0
51	48	Amasya	0.557	0.163	0.117	1
52	50	Kırıkkale	0.537	0.163	0.115	1
53	57	Osmaniye	0.523	0.161	0.111	1
54	53	Aksaray	0.524	0.159	0.114	1
55	55	Hatay	0.559	0.159	0.113	1
56	52	Kastamonu	0.524	0.158	0.114	1

Table 6. (*Continued*)

UDI Ranking	*Weighted UDI Ranking*	*Province*	*Digitalization Ratio*	*UDI*	*Weighted UDI*	*Is thera a S-C Project*
57	56	Bayburt	0.516	0.157	0.113	0
58	58	Uşak	0.505	0.153	0.108	0
59	59	Tunceli	0.503	0.151	0.108	0
60	61	Gümüşhane	0.498	0.147	0.105	0
61	60	Adıyaman	0.505	0.146	0.106	0
62	62	Tokat	0.492	0.145	0.101	0
63	63	Bartın	0.472	0.139	0.100	0
64	64	Muş	0.473	0.136	0.099	0
65	67	Bingöl	0.460	0.135	0.095	0
66	66	Çankırı	0.478	0.135	0.096	0
67	65	Sinop	0.479	0.132	0.098	0
68	68	Ardahan	0.525	0.127	0.095	0
69	69	Kars	0.455	0.126	0.091	0
70	72	Batman	0.467	0.119	0.083	1
71	70	Kilis	0.406	0.112	0.087	0
72	73	Bitlis	0.432	0.112	0.081	0
73	71	Yozgat	0.446	0.111	0.087	1
74	76	Van	0.424	0.110	0.077	0
75	74	Siirt	0.405	0.107	0.078	0
76	75	Ağrı	0.427	0.106	0.077	0
77	79	Diyarbakır	0.402	0.105	0.073	0
78	78	Şırnak	0.407	0.103	0.074	0
79	77	Iğdır	0.409	0.102	0.076	0
80	80	Mardin	0.431	0.094	0.070	0
81	81	Hakkâri	0.378	0.087	0.065	0

5. DISCUSSION and CONCLUSION

It can be said that the most important contribution of the research to the literature is the introduction of a new calculation technique called "Digitalization Rate". Because this new Digitalization Rates technique can contribute to the literature as an alternative technique to Z-Score, Euclidean Distance, and DP2 techniques in the literature. The advantage of this technique over other techniques, as can be seen from Figures 3 and 4, besides UDI calculation, can be expressed as an easy visualization of the Digital Transformation performance of cities with UDMs. In addition, the research may contribute to the literature, as it is an uncommon practice to determine the CSF weights at the indicator level instead of the dimension and CSF level in the literature.

On the other hand, Türkiye's average values given in UDMs can be used to determine the city's Digital Transformation performance for city municipalities and city administrators. By using the radar chart of the UDMs, the performance of each city's nine CSFs can be easily and visually compared with the average performance of Türkiye. According to this performance, municipalities and city managers can develop different digitalization and SC policies and strategies and take appropriate decisions and actions.

In the SC index studies listed in Tables 1 and 2, evaluations are generally made in line with the opinions of a limited number of city stakeholders. For example, the IMD 2020 EC index study is carried out in line with the opinions of 120 people selected from each city on 31 indicators. Therefore, it can be said that there is a need for models in which the index value is calculated by looking at the more integrated and objective indicator values that can be collected from different stakeholders or institutions related to the city, as in this research.

The most important limitation in this research was the dependency on IT department experts in municipalities. It was observed that especially the IT departments did not look at the e-mails they received and did not answer the phone calls. In addition, many IT officers or directors haven't answered the questions or were reluctant to answer them because they were afraid of the municipal administrations or did not have enough information or time.

When the research results shown in Table 6 are examined, it can be said that the most important result is that provinces such as Isparta, Düzce, Karaman, and Karabük are at the top. This may be the most important issue that needs to be investigated in making cities smarter or determining Digital Transformation policies and strategies. It can be considered normal for cities such as Istanbul, Ankara, Izmir, Bursa, and

Konya to be at the top of the ranks. However, the explanation of the reasons why less populous cities are at relatively the top of the list can provide important data to city municipality administrators. It is seen from the indicator ratio values that the most important common feature of these provinces is that they have a high number of university students and lecturers. It can be said that this research has revealed that universities have important contributions to the digitization and being a Smart City besides the city population, economy, and social life.

If a city is a metropolitan city, then it means that its DT level is high, which can be considered an important result in terms of showing that DT is also dependent on the population. However, it is also seen that metropolitan cities such as Van, Diyarbakir, and Mardin are among the last 10 cities in the table.

The fact that the last 20 cities in the table are predominantly from the Eastern and Southeastern Anatolia regions can be a warning for the country administrators, as it shows that Digital Transformation is a regional problem in Türkiye. Here, it can be said that the government should make more ICT superstructure investments in these regions to prevent the “Digital Divide”. Although it was stated in the phone calls made with the experts in the regional municipalities that there is no problem regarding the digital infrastructure and bandwidth due to security reasons. They said all the necessary capacity facilities are provided to the cities in this region with privilege. So, it can be said that the public, the local companies, and municipalities cannot make use of these opportunities adequately. This situation reveals that for digitization, the DT of the public or city stakeholders should be provided first. Here, the dissemination of tablets within the scope of the EBA and FATIH project may be an appropriate superstructure investment to popularize the use of digital technology by the public and especially the school-age population. In addition, it can be considered to provide free internet to the students of the region by the municipalities and governorships.

On the other hand, the cities with the Smart City project are at the top of the list in the table which can be seen as an important finding of the research in terms of showing that the goals of being a Smart City and Digital Transformation are compatible. It has been observed that cities such as Kayseri, Konya, Denizli, Bursa, Erzurum, and Balıkesir, which carry out the SC project seriously, use Industry 4.0 technologies such as Artificial Intelligence, Cloud Computing, Artificial Neural Networks, and Open Data Portal effectively.

With the help of the indicator ratios calculated in the research, cities can be compared in detail based on indicators, so that their strengths and weaknesses can be revealed. According to the results of this evaluation, cities can develop strategies to increase their competitiveness in the context of Digital Transformation. For this, it can be suggested that detailed analyzes of the research results based on indicators should be made. In addition, the fact that each province has different UDI values and UDMs shows that each provincial center needs different administrative decisions regarding Digital Transformation and that the indicators should be analyzed in detail in determining the needs of each.

The weighted and unweighted UDI rankings determined in the research can help city administrators to determine future urban digitalization and SC policies and to develop new SC strategies. However, the UDI ranking results in the table should not be perceived as just a general ranking list. Because the Digital Transformation ranking and level of cities can help increase the competitiveness of cities in the world, ensure their sustainability, maintain their economic development, use urban resources effectively and productively and protect their ecological balance.

Unfortunately, the results of this research could not be compared with the results of any other research, as there was no suitable data-based research in Türkiye on the Digital Transformation of cities in 81 city centers during the research. For example, in the (Akdamar, 2018) research conducted in this area, it is clear that there would be no point in making comparisons because cities in Türkiye were not analyzed and very different analysis methods and data sets were used. In the Aihemaiti (2018) research, which is most similar to this research, the results could not be compared with this research, since virtual data was used. For example, in the Aihemaiti (2018) research conducted on 40 cities, Istanbul is 25th and Balıkesir is the first.

Also listed in Table 2, the research conducted by Vodafone-Deloitte in 19 metropolitan municipalities in 2016, the “Türkiye Smart Cities Evaluation Reports” published by the Turkish Informatics Foundation (TIF) on March 1, 2016, and the SC evaluation reports prepared by İstanbul Metropolitan Municipality (IMM) are generally based on municipal data and since there are research reports using many different dimensions, CSF and indicators, a comparison with these studies could not be made.

The only research with which this research can be compared can be the "Smart City Maturity Evaluation Model" conducted by the Ministry of Environment and Urbanization-Smart Cities and Geographical Technologies Department, listed in Table 2. However, these research results and the methods used are not publicly published. It can be suggested that the UDI calculation model developed in

this study should be used in the evaluation of the data results of the "Smart Cities Maturity Assessment Model".

As can be understood from these explanations, this research can be seen as the first and only research conducted based on 81 provinces in Türkiye as a Digital Transformation and Smart City indexing research.

As a result, if cities are considered as an ecosystem, it can be said that there are no urban or urbanization problems, but there are "unurbanization" problems. In short, all city stakeholders should be reminded that the problem and solution are not in cities or technologies, but in the people living in the city. Therefore, determining the stage of the Digital Transformation of cities can be considered as an important issue and a solution to this issue has been sought in this research. In addition, it can be suggested as a yearly important practice to follow the development of cities by repeating this research, which measures how much the people, educational institutions, businesses, technological infrastructure, municipality, and economic structure are digitized.

It should not be forgotten that Digital Transformation is not only a technical issue but also a new technology developed for cities and countries to serve their citizens, as well as a social, economic, and managerial transformation. So, the Digital Transformation of cities is not only a technological and temporary change but an intergenerational transformation, where it can be suggested that city services be digitized according to the "Z-Generation". As a result, it can be said that cities and humanity have begun to evolve into very different political, economic, social, and technological worlds.

Conflict of Interest

No potential conflict of interest was reported by the author.

Funding

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Compliance with Ethical Standards

It was declared by the author that the tools and methods used in the study do not require the permission of the Ethics Committee.

REFERENCES

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I. and Airaksinen, M. (2017). "What are the Differences between Sustainable and Smart Cities?", *Cities*, 60, 234-245.

Aihemaiti, A. (2018). "Türkiye'deki Akıllı Şehirlerin Sıralama Modeli", Master Thesis, İstanbul Commerce University Graduate School of Applied and Natural Sciences, Istanbul.

Akdamar, E. (2018). "Akıllı Kentlere İlişkin ISO 37120 Standardı Göstergelerinin Çok Değişkenli İstatistiksel Tekniklerle İrdelenmesi", PhD Thesis, Uludağ University Social Science Institution, Bursa.

Akıllısehirler.gov.tr. (2020). "Olgunluk Değerlendirme Modeli", https://www.akillisehirler.gov.tr/olgunluk-degerlendirme-modeli/, (Access Date: 21.11.2020).

ATGM (2020). "Tasarım Merkezleri", https://www.sanayi.gov.tr/istatistikler/istatistiki-bilgiler/mi0203011503, (Access Date: 14.6.2020).

ATGM (2020a). "Teknoloji Geliştirme Bölgeleri", https://www.sanayi.gov.tr/istatistikler/istatistiki-bilgiler/mi0203011501, (Access Date: 14.6.2020).

ATGM (2020b). "Ar-Ge Merkezleri", https://www.sanayi.gov.tr/istatistikler/istatistiki-bilgiler/mi0203011502, (Access Date: 14.6.2020).

Berger, R. (2019). "The Smart City Breakaway, How a Small Group of Leading Digital Cities is Outpacing the Rest", https://www.rolandberger.com/publications/publication_pdf/roland_berger_smart_city_breakaway_1.pdf, (Access Date: 20.8.2020).

BTGM. (2019). Teknoloji Geliştirme (Teknokent) Bölgeleri, https://btgm.sanayi.gov.tr/Handlers/DokumanGetHandler.ashx?dokumanId=4d9b6b9a-839b-446e-af35-aafe40b65946, (Access Date: 22.10.2019).

BTK. (2019). "Türkiye 2019 İletişim Hizmetleri İstatistikleri", https://www.btk.gov.tr/uploads/pages/iletisim-hizmetleri-istatistikleri/istatistik-2019-4-5ec51cf389753.pdf, (Access Date: 8.6.2020).

CBS Müdürlüğü. (2019). Akıllı Şehirler Beyaz Bülteni, https://webdosya.csb.gov.tr/db/cbs/akillisehirler/, (Access Date: 24.12.2019).

Cİ. (2020). Türkiyenin Coğrafi İşaretleri, https://www.ci.gov.tr/anasayfa, Access Date: 10.5.2020.

Cisco (2018). "Cisco Australian Digital Readiness Index 2018 Digital Dividend or Digital Divide?", https://www.cisco.com/c/dam/m/en_au/digital-readiness/pdfs/digital-readiness-report.pdf, (Access Date: 20.8.2019).

Cohen, B. (2012). "What Exactly is a Smart City", https://www.fastcodesign.com/1680538/what-exactly-is-a-smart-city, (Access Date: 16.5.2018).

Cohen, B. (2015). "The Smartest Cities in the World 2015: Methodology", https://www.fastcompany.com/3038818/the-smartest-cities-in-the-world-2015-methodology, (Access Date: 27.10.2019).

Coruh, M. (2009). "The Factors Involved in Utilizing e-Municipality and Municipal Wireless Network (MWN) Technologies for Effective, Efficient, and Productive Use of City Resources in Municipal Governments in the Information Age", PhD Thesis, International School of Management, Paris.

Çoruh, M. (2021). "Çok Kriterli Karar Verme Tekniklerine Dayalı Yeni Bir Kent Dijitalleşme Endeks Hesaplama Modeli Önerisi: Türkiye Uygulaması", PhD Thesis, Sakarya University Graduate School of Business, Sakarya.

Çoruh, M. and Cebeci, H. (2020). "Zonguldak İli Kentlerinin Kent Dijitalleşme Endekslerine Göre Sıralanması ve Dijitalleşme Seviyelerinin Kent Dijitalleşme Haritaları ile Görselleştirilmesi", *İdealkent*, 11(30), 621-647.

EDCi (2016). "European Digital City Index Methodology Report", https://digitalcityindex.eu/uploads/2016%20EDCi%20Construction%20Methodology%20FINAL.pdf, (Access Date: 20.8.2020).

Eğitim-Sen (2018). Türkiye'de Ortalama Okul Süresi (Yıl), http://egitimsen.org.tr/2018-2019-egitim-ogretim-yilinda-egitimin-durumu-raporu/, Access Date: 8.10.2019.

Habertürk (2019). Türkiye'de Ortalama Yaşam Beklenti Süresi (Yıl), https://www.haberturk.com/turkiye-de-beklenen-yasam-suresi-78-3-yil-2524926, (Access Date: 9.10.2019).

Herzberg, C. (2017). "Akıllı Şehirler Dijital Ülkeler", Infoloji Smart Solution, Optimist Yayın Grubu, Istanbul.

IBM (2016). "How Smart is Your City?, Helping Cities Measure Progress", https://www.ibm.com/downloads/cas/KLEYQE6Z, (Access Date: 30.8.2019).

IMD (2020). "Smart City Index Summary of Criteria", https://www.imd.org/smart-city-observatory/smart-city-index/, (Access Date: 22.8.2021).

Invest (2019). “Türkiye'de Uluslararası Doğrudan Yatırım Tutarları (2002-2019)”, http://v1.invest.gov.tr/tr-TR/investmentguide/investorsguide/Pages/FDIinTurkey.aspx, (Access Date: 6.6.2020).

Kamrysi, K., Gotzamani, K., Andronikidis, A. and Georgiou, A.C. (2014). “Capturing and Prioritizing Students’ Requirements for Course Design by Embedding Fuzzy-AHP and Linear Programming in QFD”, *The European Journal of Operational Research*, 10831094.

Kayan, A. (2019). “Dijital Çağda Kent Yönetimi İçin Ortaya Çıkan Fırsatlar”, *Sayıştay Dergisi*, 114, 53-73.

Keleş, R. (2008). “Kentleşme Politikası”, 10. Edition, İmge Kitapevi, Ankara.

KOBİTEK (2014). Toplam Firma Sayıları, https://kobitek.com/turkiyede-kac-sirket-var, Access Date: 22.10.2019.

Nick, G. and Pongrácz, F. (2016). “How to Measure Industry 4.0 Readiness of Cities”, International Scientific Conference: Industry 4.0, http://industry-4.eu/winter/sbornik/2016/2/16.HOW%20TO%20MEASURE%20INDUSTRY%204.0%20READINESS%20OF%20CITIES.pdf, (Access Date: 21.8.2019).

Nick.tr. (2019). Toplam TR Alan Adları İstatistikleri, https://www.nic.tr/index.php?USRACTN=STATISTICS, Access Date: 7.6.2020.

Satyam, A. (2017). “The Smart City Transformations (e-Book)”, Bloomsbury Publishing India Pvt. Ltd., New Delhi.

SBB. (2019). Merkezi Yönetim Bütçesi, http://www.sbb.gov.tr/wp-content/uploads/2020/02/MerkeziYonetimButceGerceklesmeleriveBeklentilerRaporu2019.pdf, (Access Date: 8.6.2020).

SCRanking (2007). “Smart Cities-Ranking of European Medium-Sized Cities”, http://www.smart-cities.eu/download/smart_cities_final_report.pdf, (Access Date: 20.8.2019).

SGB (2019). Yetişkin BT/Bilgisayar/Programcılık Kursu Veren Kurum Sayısı+Halk Eğitim Merkezi, https://sgb.meb.gov.tr/www/icerik_goruntule.php?KNO=361, (Access Date: 23.10.2019).

SGK (2019). “SGK İstatistik Yıllıkları”, http://www.sgk.gov.tr/wps/portal/sgk/tr/kurumsal/istatistik/sgk_istatistik_yilliklari, (Access Date: 8.6.2020).

TİM (2019). Türkiye'nin İhracat Tutarları, https://www.tim.org.tr/tr/ihracat-rakamlari.html, (Access Date: 8.6.2020).

TOBB (2019). Kurulan-Kapanan Şirket İstatistkleri, https://www.tobb.org.tr/BilgiErisimMudurlugu/Sayfalar/KurulanKapananSirketistatistikleri.php, (Access Date: 8.6.2020).

TÜBİSAD. (2020). Türkiye’de e-Ticaret 2019 Pazar Büyüklüğü, İstanbul: Türkiye Bilişim Sanayicileri Derneği, April 2020, http://www.tubisad.org.tr/: http://www.tubisad.org.tr/tr/images/pdf/tubisad_e-ticaret_2019_pazar_buyuklugu_raporu.pdf, (Access Date: 12.12.2020).

TUİK (2019a). Şirketlerin Bilgisayar ve Web Kullanım Oranları, http://tuik.gov.tr/PreHaberBultenleri.do?id=30573, (Access Date: 22.10.2019).

TUİK. (2020). 2020 Adrese Dayalı Nüfus Kayıt Sistemi Sonuçları, https://data.tuik.gov.tr/Bulten/Index?p=Adrese-Dayali-Nufus-Kayit-Sistemi-Sonuclari-2020-37210&dil=1, (Access Date: 5.2.2021).

TUİK. (2020a). Hanehalkı Bilişim Teknolojileri (BT) Kullanım Araştırması, 2020, https://data.tuik.gov.tr/Bulten/Index?p=Hanehalki-Bilisim-Teknolojileri-(BT)-Kullanim-Arastirmasi-2020-33679, (Access Date: 20.11.2020).

Turk Telekom (2018). Türk Telekom ile Güçlü Belediyeler, Mutlu Vatandaşlar, Türk Telekom Smart Cities Catalog, İstanbul.

TürkPatent (2019). “Patent İstatistikleri”, https://www.turkpatent.gov.tr/TURKPATENT/statistics/, (Access Date: 6.6.2020).

Vodafone (2016). Akıllı Şehir Yol Haritası, https://www.vodafone.com.tr/VodafoneBusiness/iot/pdf/akilli-sehir-yol-haritasi.pdf, (Access Date: 24/12/2019).

YÖK (2020). “Yüksek Öğretim Bilgi Sistemleri Istatistikleri”, https://istatistik.yok.gov.tr/, (Access Date: 08.06.2020).