Business Intelligence Dashboard for Smart, Sustainable and Resilient Cities based on the City's Fundamental Power Index

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Abstract

The paper addresses the development of Business Intelligence management dashboards for sustainable, smart and resilient city. It highlights benefits and requirements of the use of data visualisations to communicate information to support decision-makers and the local community in understanding of the complex dependencies between city's different functional areas. The goal of the paper is to show the original City's Fundamental Power Index constructed to evaluate the city from the perspective of a sustainable, smart and resilient city. The dashboard based on the index uses the set of data at city level provided by the Statistics Poland and National Electoral Commission. The comparative analysis applies taxonomic measure of development. The applied method and the results obtained can be used for different cities also in subsequent years to examine the results of strategic management in the implementation of sustainable, smart and resilient development policy.

Keywords: smart city, city dashboards, city index, resilient city

1. Introduction

The management of a city is a complex, challenging, and continuous process [1, 2]. It consists of analyses, collection of opinions from different stakeholders [3, 4] and is determined by legal conditions [5] available funds, a management method and many other factors [6]. All these elements generate data that are used in the decision-making processes taking place in public administration agencies. Data from the basic operations of municipal officers (internal data) can be combined with data from external sources such as the social media, smart sensors or data from city apps (external data). Various indicators constructed on the basis of such data make it possible to analyse a process and acquire valuable information derived from such raw data. Such indicators support the implementation and the management of the development of smart cities; visualising them promotes an understanding of the complex dependencies between city's different functional areas. No systematic and comprehensive system for transforming usually unstructured and heterogeneous urban data into a coherent system to support decision-making has been developed yet [2].

Designing data visualisation entails the availability of knowledge covering issues related to statistics, analytics and the use of technologies and appropriate tools such as systems for the generation of visualisations, programming mechanisms and databases [7]. However, in order to present the appropriate information well on city dashboards, one

needs the formulated development strategy on the one hand and knowledge of how public administration works on the other hand, as well as appropriate skills. These conditions are necessary to combine the data coming from various sources correctly so that the generated information is useful and understandable. The accurate presentation of data is also facilitated by a good knowledge of its audience, especially of the decision-makers and the local community [8].

This paper is to present the proposal of management dashboard as the management information systems showing the original City's Fundamental Power Index constructed to evaluate the city from the perspective of implementing the concept of a sustainable, smart and resilient city. In recent times, due to the unexpected facts, such as COVID'19 or unstable situation in many countries, it is important to promote solutions for the cities to become more resilient and adapt to new situation. The presentation of indicators in the form of charts, labels or maps can be used for communication with the citizens, which will help the society better understand functions of the city in different areas, such as possibilities to get funds to recover from the pandemic. They help improve transparency and trust in the local government. The assumption that lays the ground for the paper is that the use and updates of the Index contribute to the implementation of the sustainable city, smart city and resilient city concepts.

In the light of these facts, the main objective of the paper is to design a dashboard supporting the decision-making process in a smart, resilient and sustainable city by visualising the original City's Fundamental Power Index. The following research questions are answered in this paper:

1. What conditions should a city dashboard meet for it to be an understandable and useful source of information to support decision-making?
2. How can a visualisation of the City's Fundamental Power Index influence the implementation of the smart city and smart resilient city concept?
3. What benefits can data visualisation in the form of a dashboard bring about for the city?

Achieving the formulated objective and answering the questions posed required dividing the work into five sections (Tab.1). The first three sections were based on an analysis of the literature and a review of existing solutions to examine the design of urban dashboards from a theoretical perspective and from the point of view of the tools used. The first section is a review of the literature related to the use of dashboard information visualisations by public administrations. In the second section, key characteristics of a well-designed dashboard and tools to present data graphically are described. The third section covers an analysis of selected city dashboards from the perspective of requirements described in the previous part. Further sections focus on materials, methods and results. It uses the set of data provided by the Statistics Poland and National Electoral Commission for 18 voivodeship capital cities of Poland for the period of 2014-2020 and applies the taxonomic measure of development. The fourth section presents the City's Fundamental Power Index and its visualisation. The last part contains the presentation of results of the designed visualisation, the discussion about benefits of its use for the city and the summary. The research used the method of logical design, experiment, comparative analysis, and survey to propose and discuss the dashboard. The opportunity to experience day-to-day work in one of the local administration units was also a helpful source of information. This paper develops the research published by authors in 2021 [9].

Table 1. Research design

No.	Research step	Method
1	Identification of research topics (clusters) related to data visualisation	Literature review
2	Determinants of the quality of data visualization	
3	Analysis of selected city dashboards	
4	Development of dashboard	Materials, methods and results
5	Benefits and challenges related to the use of data visualization – city perspective	Discussion and conclusion

Source: Own study.

Therefore, this paper follows the public management strand and refers to the smart city

concept and its implementation using dashboards in order to support managing a complex urban system. As the concepts of smart city and city dashboards are not new, the novelty of the research and research gap refers to the City Fundamental Power Index (a new measure for socio-economic development) incorporating the concept of the sustainable, resilient and smart city and its application with city dashboards. It can be then useful for public managers to provide support for decision-making and for communicating with citizens.

2. Essence and quality factors of the presented information

The quality of the information presented with the use of dashboards is influenced by the clarity of their design. Basic types of data visualisation include bar and pie charts, maps and 3D objects [10]. It is important to use an appropriate type of chart to clearly and comprehensibly reflect the essence of the information presented. The use of an appropriate graph matched to the data contributes to a better understanding of the information communicated through it. Additionally, the use of an appropriate presentation (based on appropriate indicators) influences the decisions being made, as it allows their effects to be monitored, also in the form of negative deviations, which makes it possible to correct the actions. However, the use of single graphs tailored to the data may turn out to be insufficient due to the amount of data that needs to be considered to comprehensively present a particular phenomenon [11]. The visualisation has to consider the individual values of indicators and also the change of a particular phenomenon over time. Therefore, dashboards are used to visualise a lot of information. They make it possible to visualise data aggregated to a varied degree on a single sheet so as to present as comprehensive an overview as possible to the recipient.

In order to guarantee the appropriate quality of the presented information in the dashboard design process, one needs to take nine construction rules into account (Table 2).

Table 2. Rules for constructing dashboards for smart cities

Guidelines	Design Focus	Suggestions
1. Navigation	Implementation of easy and logical navigation that will allow city stakeholders to easily find the information they are interested in, taking into account the specific hierarchy of detail of the selected data.	If the city stakeholders take a wrong turn, facilitate menu functions that help correct unintended actions. Also, provide users with 'accelerators' to speed-up navigation and facilitate frequent actions.
2. Data Utility	The intended meaning of the data being presented must be explicit and have actionable applications for diverse user types with different data literacies.	By design, data in a smart city is directed to city stakeholders. To convey data in an understandable way, the dashboard should use clear, consistent terminology, words, phrases and concepts familiar to residents.
3. Style	The overall look and feel should be representative of the city and should be applied consistently to help build familiarity and confidence as well as improving the overall city stakeholders experience.	There should be no ambiguity in the look and feel of the user interface; all pages and themes should remain the same throughout the different areas of the dashboard, taking into account, for example, the colors characteristic of the city.
4. Visualisations	Data visualisations should be of a suitable type and have further contextual information or metadata attached for clarity of meaning.	Think about consistency and relevance in the use of all visualisations and dialogues, and actively support city stakeholders in building knowledge. Dashboards can have the function of downloading historical data for use by city stakeholders, for example, to create applications useful for the city.
5. Veracity	The accuracy, precision, lineage, source, and age of data must accompany all data.	Ambiguous or untrustworthy data should not be used. Provide links to data sources so that users can also access and asses the veracity of data. The given sources of city data should be additionally properly secured and anonymised.
6. Users	Potential user-types for city dashboards are broad; therefore, implement user-centred design methodologies for all system development workflows to build empathy with the different user types of dashboard systems.	The potential types of users of city dashboards are its residents; therefore, implement resident-centred design methodologies to build trust in public administration.
7. Data Types	Use both real-time and historical data; arrange them logically and group them thematically, for example, using the six-dimension smart city: Smart Government, Smart Economy, Smart Environment, Smart Living, Smart Mobility, and Smart People.	Include real-time data to assure city stakeholders that data are current, as well as displaying time-series data to provide further context and encourage data exploration.

8. Usability	Usability heuristics should be applied at all stages by all project team members.	Use heuristics to provide users with explorable information, usable interfaces, and learnable interaction methodologies that are informed via validated HCI research. Such action will allow the public administration striving for a smart city to include city stakeholders in the decision-making process using the dashboard as a tool for participation.
9. Communication	Use effective language and appropriate visualisations to communicate meaning across multiple platforms, media, and via multiple modalities if possible.	The right choice of a tool for visualizing city data is determinate from the point of view of proper understanding of the published data. Therefore, it is important to understand the expectations of city stakeholders to make the data available useful for them.

Source: Own study based on [12].

3. Smart city dashboards – selected examples

Developments in technology mean that the amount of data produced and collected is constantly increasing, which in turn leads to the search for further insights from their analysis [13]. Combining and presenting data graphically makes it possible to create the information from the data that is an integral factor in the decision-making process. An increase in the amount of data and the desire to transform it into information have led to the development of a number of data processing tools [14].

Research on the use of specialized systems for data visualization, conducted by Cepero, Montané-Jiménez and Toledo-Toledo [8], indicates frequently used tools for visualizing urban data, such as:

- a spreadsheet,
- systems and applications used by institutions as part of their core business,
- open data portals,
- digital globes, e.g. Google Earth,
- GIS systems,
- business intelligence systems (Microsoft Power BI, QlikView, Tableau),
- building information modeling (BIM).

The presentation of various types of information by the local public administration through dashboards is in line with the principles underlying the idea of an open government [15, 16]. The principles of open government are transparency, open data provision, interoperability, the ability to apply new technological solutions, democracy and the citizens' participation in the making of decisions made for the common good [17]. Additionally, data aggregated into various indicators and presented in a graphical format make it possible for the local administration, for example, to monitor the efficiency of the management of city services. Efficiency is understood in this context as the time and expense necessary to execute a planned action in a way that minimises expenditure and unnecessary effort [18]. Therefore, the visualisation of data, the appropriate understanding and use of it are important aspects of management in compliance with the smart city concept. The provision of information to the public through the use of graphs or maps showing, for example, implementation levels of specific tasks, facilitates communication and the participation of residents in the planning and evaluation of the activities undertaken by the administration. One of ways to do it is to design and implement solutions aimed at solving important problems of the urban community and improving its living conditions [19].

In the context of the smart city concept, data visualization is based on the use of data streams generated by cities as part of their core business [20]. This can be data from geographic information systems that can be analyzed in real time using tools such as ArcGIS. In order to use the collected information in the decision-making process of city's authorities and to publish visualizations to city's stakeholders, models and solutions built for the needs of specific cities were developed, such as [21]:

- Search-the-City, which enables the analysis of city data from various sources including sensors, cameras, social media or data created by the city administration,
- City Feed which is a system based on crowdsourcing, providing government data that is transformed, published in social media or via other services and integrated with tools that

allow the assessment of selected parameters and the inclusion of these values in the decision-making process.

On the basis of their research that involved the collection of opinions of dashboard users provided by cities and the determination of their usability, Young and Kitchin identified the inconveniences associated with the use of resources made available. Most important of them include [12]:

- the vocabulary used to describe the data was too technically complex, resulting in users being unable to select the information of interest and giving up on further exploration of the topic;
- the lack of properly designed auxiliary and explanatory materials such as tutorials for deeper data exploration;
- an excessive number of stages to complete in order to visualise the data properly, which should be limited to a few clicks; relationships between data should be logical and easy to explore.

Considering the rules (Tab. 2) related to elements that the dashboards provided by cities should include, selected dashboards were analysed (Tab. 3). The elements included were marked with the (x) sign in the table.

Table 3. Comparison of the construction of selected city dashboards

City	Navigation	Data Utility	Style	Visualisations	Veracity	Users	Data Types	Usability	Communication
London (UK)		x	x	x	x			x	x
Edmonton Canada	x	x		x		x	x	x	
Glasgow Scotland									
Bandung Indonesia		x	x	x				x	
Valencia Spain	x	x	x	x	x			x	x
Włocławek Poland			x						x

Source: Own study.

The comparison of conveniently selected city dashboards shows that nearly all of the above-mentioned cities allow the user to navigate the graphical data presentation by its visualisation on charts and maps. However, the visualised data are only presented for a single period with no possibility to filter dates or to overlay other information on the graph. Additionally, the information cannot be selected for a specific group of target users. In nearly all of the selected cities, the style was adapted to the general image of official websites of such cities. In London's case, a dashboard fits into a single page with no need to search for any additional information on separate sheets or tabs. This improves readability and is in line with the overall design assumptions for dashboards as they should present the most relevant information in a single tab. Numerous references to subsequent subsites may ultimately make users lose interest in learning more about the city.

The analysis of selected city dashboards has also shown that countries such as Australia or Thailand have dedicated websites with data relating to many cities summarised in the form of dashboards. This is a uniform and convenient way to provide the interested parties with interesting data, but it does not reflect the individuality of any specific city. The users' communication with a city whose data they look for is also limited in this case.

4. City dashboards and City's Fundamental Power as a tool in the development of smart city

4.1. City's Fundamental Power Index – materials and methods

There are many concepts of urban development. Most important of them include the sustainable city, smart city and resilient city concepts. Each of these concepts corresponds to certain specific characteristics attributed to them. A sustainable city maintains the balance between

respect for the natural environment, and the use and the generation of economic and social resources. The concept of sustainable development emerged in the 1980s [22]. It shaped urban development and is an implemented policy both worldwide (Agenda 2030 and 17 Sustainable Development Goals) and locally [23]. The 'triple bottom line' shows the interrelationship between and co-dependence of social, economic, and environmental dimensions of the city [24]. A smart city based on the assumption of sustainable development supports the management processes in the area of the economy, people, governance, mobility, environment and life by applying an innovative technology. Dimensions of the smart city concept are grounded in traditional and neoclassical theories of urban development and growth, including regional competitiveness theories, transport economics and ICT, and issues of human and social capital and quality of life theories [25]. In turn, the essence of a resilient city is in its ability to regenerate following shocks caused by crises, disasters and economic, social or environmental catastrophes [26]. Urban resilience means that the city maintains or is able to return to the path of development following these shocks. It is the ability of a vulnerable and integrated city systems to capture, absorb, adapt and rebuild after shocks of any nature [27].

Eventually, the collected variables were combined into synthetic indicators corresponding to each of the concepts, and their aggregation made it possible to create the City's Fundamental Power Index. The assumption is that the use and the ongoing updates of the Index for a selected city is to contribute to an improvement of the implementation of actions taken by the city individually in each of the areas such as the sustainable city, smart city and resilient city as well as holistically, from the perspective of the City's Fundamental Power.

The data on the basis of which the discussed Index was developed came from the Statistics Poland [28] and the National Electoral Commission [29]. The data were collected for 18 voivodeship capital cities of Poland for the period of 2014-2020. After the initial collection of variables was set, variability and the correlation between variables was measured. Variables characterised by low variability (variability coefficient below 5%) or strong correlation with other variables (Pearson's coefficient above 0.8 or below -0.8) were removed. The general structure of 100 variables, together with areas and count of variables (after variables of low variability or high correlation were removed) is shown in Figure 1. Finally, 32 variables were taken under consideration for the purpose of sustainable city indicator, 48 variables for smart city indicator and 20 for resilient city indicator. The variables have been selected based on the literature review and validated by existing rankings including IESE Cities in Motion, Global Liveability Index, Green City Index, Smart City Index, Global Power City Index (GPCI) [9].

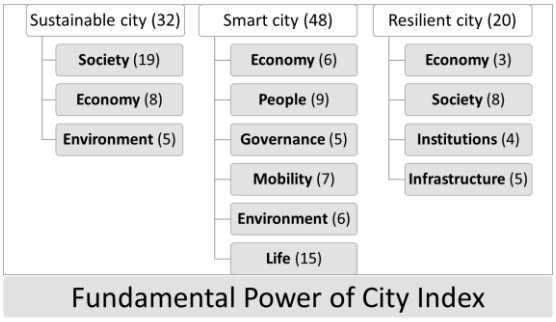

Fig. 1. Summary of variables sets in the study (number of variables in the brackets). Source: own study.

In order to rank cities, Hellwig's Taxonomic Measure of Economic Development approach was used [30]. Selected variables were identified as stimulants (for which higher values are preferable) or dis-stimulants (for which lower values are preferable). Variables were standardised according to the formula:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j} \quad (1)$$

where x_{ij} is a value of variable j for city i, $\bar{x}_j$ is the mean for variable j and s_j is the standard

deviation for variable j.

Next, two hypothetical objects – the 'pattern' and 'antipattern' –were created. The pattern is assigned the best possible value for each variable, which is the maximum value in the dataset for stimulants and the minimum value in the dataset for dis-stimulants., The worst possible values are assigned to the antipattern, so the minimum value in the dataset is for stimulants and maximum value in the dataset is for dis-stimulants. The Euclidean distance between pattern and each object (d_{i0}) was then calculated as follows:

$$d_{i0} = \sqrt{\sum_{j=1}^{p}(z_{0j} - z_{ij})^2} \tag{2}$$

where:
d_{i0} = Euclidean distance between city i and pattern, z_{0j} = value of variable j for the pattern, z_{ij} = value of variable j for city i.
Euclidean distance between pattern and antipattern d_0 was also calculated.

The taxonomic measure is then obtained for each city using the formula [31]:[1]

$$m_i = 1 - \frac{d_{i0}}{d_0} \tag{3}$$

This measure takes values between 0 and 1, with 1 meaning the object is the pattern, and 0 is the antipattern.

Firstly, the measure of sustainability, of intelligence and of resilience was calculated for each city to enable ranking. Secondly, after 20 repetitive variables were removed, the 80 variables representing the sustainable, smart and resilient city were aggregated to form the synthetic value of the Fundamental City Power Index. During both phases all variables were given the same weight in the calculations.

4.2. Visualisation of the City's Fundamental Power Index in the context of the smart city concept – results

In order to produce a graphical representation of the data collected for the construction of the author's Index, the data first had to be properly prepared. In particular, proper data visualisation depends primarily on the quality of the data that will feed the Business Intelligence system used in the solution designed for this research. The ETL (Extraction, Transformation, Loading) method assumes data extraction from a source (extract) followed by their transformation into an appropriate format and, finally, loading them to an appropriate system [32]. In view of the above assumptions, data preparation according to the ETL method consisted of arranging the data in such a way that the target data had an appropriate timestamp and were directly related to the other characteristics (changing the data orientation from column to row-based). Finally, the properly prepared data were transferred to Microsoft Power BI in order to visualise indicators of the City's Fundamental Power Index.

Figure 2 presents an example of a dashboard divided into two parts. The left side presents visualisations of the City's Fundamental Power Index — Gdansk in Poland (capital of Pomeranian Voivodeship) was chosen in the presented case. The right side shows the value of the indicator presenting the average for the cities in Poland included in the research. In the data preparation process, an expected value of 0.5 was added to the compilation of indicator values for individual cities and years in order to establish a benchmark and a level to which the city should aspire in its development process.

[1] In his work Hellwig used a slightly different formula for the value of the measure of economic development. The approach used in this paper was described by [31].

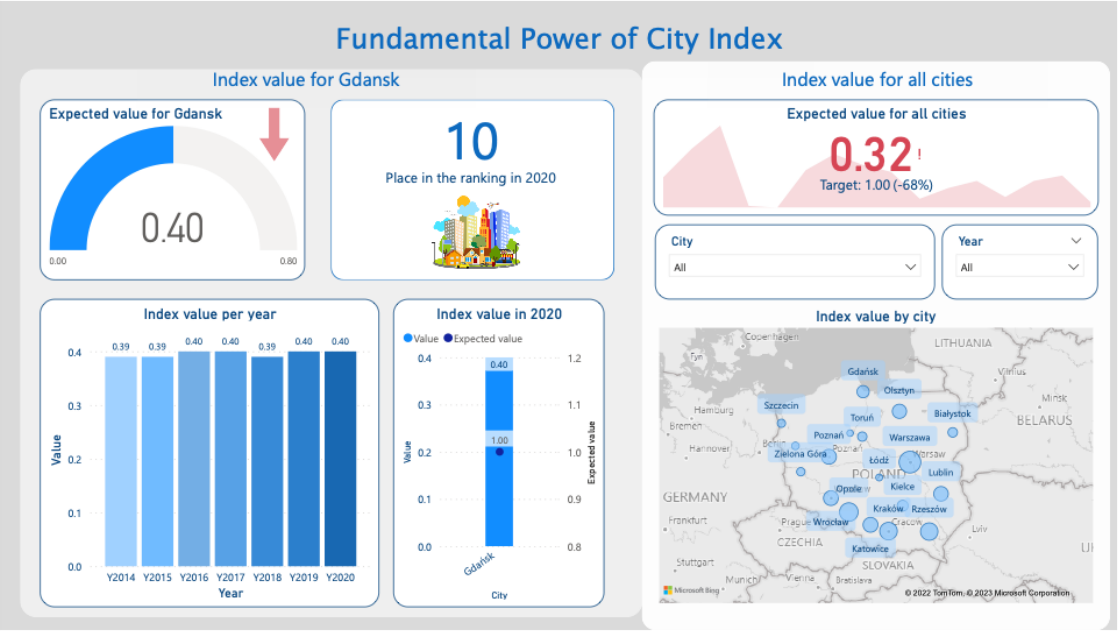

Fig. 2. Dashboard of City's Fundamental Power Index. Source: Own study.

Additionally, the detailed information on the implementation of the smart, sustainable and resilient city concepts can be extracted from the factors comprising the original City's Fundamental Power Index. The presentation of parameters for one of the six dimensions of the smart city concept is shown in Figure 3.

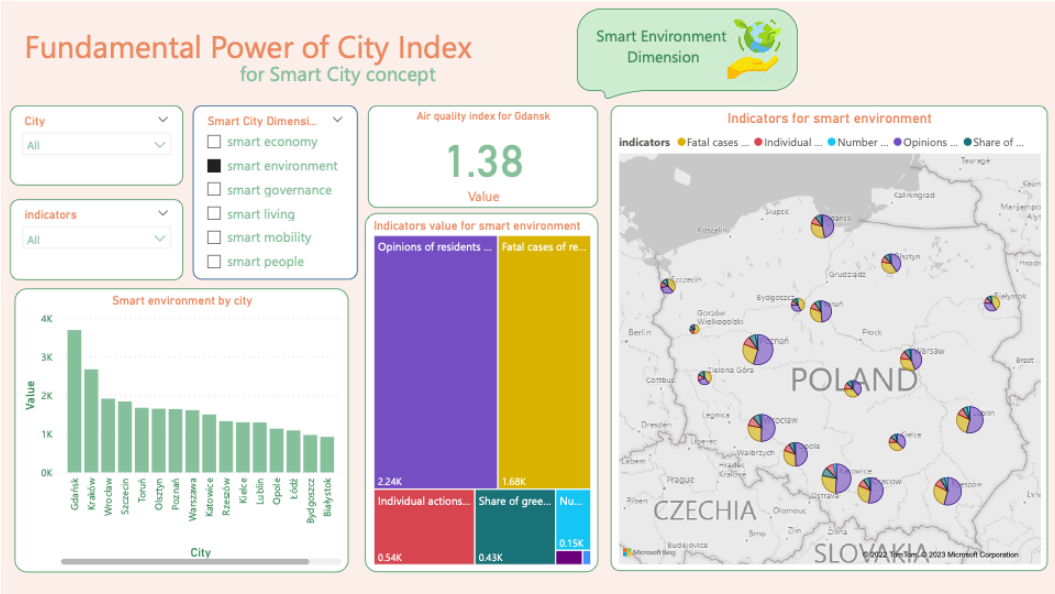

Fig. 3. Dashboard of the City's Fundamental Power Index for the smart city concept. Source: Own study.

According to the smart city concept, the analysis and measurement of urban development should be conducted considering the following six areas: the economy, people, management, mobility, environment and the quality of life (Figure 3). In this way, the use of the City's Fundamental Power Index can support the implementation and monitoring of activities in each of the smart city subareas. The smart environment dimension of the smart city concept was chosen as an example. Through the use of slicers, it is possible to filter the data to be presented in the diagrams. The single data sheet containing the air quality value as well as the values presented on the tree map and the traditional map can be adapted to meet the information needs of the people to whom the visualisation will be addressed by indicating only the most relevant information. The original Index described in this paper contains data expressed in various units,

which is why only those whose measurements are similar to each other have been selected for the purposes of compiling the dashboard (applies to maps). This approach was adopted to retain the transparency and aesthetics of the information presented; however, it also entails the risk of manipulation of the data interpretation by using specific presentations.

5. Results and discussion

As mentioned in the introduction, the modern city should be smart and resilient to adapt to rapid changes in the world, such as COVID'19. One of the aspects is communicating the citizens about current situation in transparent way. This communication component can be a part of the Business Intelligence management dashboards which may show how the city respond to the new phenomenon.

Based on the research, it can be confirmed that cities offer wide access to various types of data that, when properly processed, can help forecast and understand trends and notice patterns [2]. Even though the Index used the official data only from the Statistics Poland and National Electoral Commission, the information used in cities to create the dashboard can include, among others [33]:

- data from websites of rescue services (problems of policing, security, fire access, ambulance access),
- urban planning (location, positioning of buildings, types of infrastructure),
- telecommunication data (the number of connections to the public network, applications used, most frequent paths taken),
- tourism (places most frequently visited, the number of tourists),
- environmental data (air pollution levels, noise levels, green areas),
- City Portals (the number of provided electronic services, the number of documents submitted to agencies in electronic formats),
- education and learning (the number of children attending schools, education level, the use of innovative teaching method, the number of schools).

The graphic visualisation of data listed above contributes to a better understanding of them as also indicated by Kourtit & Nijkamp [2]. In the era of the technological revolution and Big Data, data visualisation is of key importance for the analysis of the data continuously generated by cities for the making of decisions based on the collected resources [34].

The range of benefits of using visualisation as a form of presenting large amounts of data in an attractive way, there are also barriers that contribute to the abandonment of dashboards by public administrations. When it comes to the smart city concept, the ability to represent data graphically appears to be particularly important, as one of the key prerequisites for the development of the smart city is the generation and processing of data [35]. Cities aspiring to be smart cities should have a suitably qualified workforce with programming, analytical and graphical skills and knowledge of how the city functions and is managed. Simply being able to take data and put it on a graph will not make it communicate information more effectively. The balance between the form of presentation and the purpose of the visualisation (the function it is intended to perform and for which audience it is to be prepared) is an important aspect. Data selected for the generation of city dashboards should be properly prepared and aggregated into new measures to present it in an attractive and understandable way. Programming languages such as M and DAX can be applied for this purpose. However, the practical application of the properties of such programming tools can be very time-consuming and often even impossible as many public administrations lack internal knowledge or capacity to extract the data they hold in a way that makes the data suitable for further processing. As a result, seeing unknown correlations and relationships between different phenomena may become difficult, even though it is one of the main benefits of creating visualisations of urban data [36].

Information overload is typical for our times. Large amounts of data can overwhelm and discourage one from exploring it. The amount of data generated by cities continues to increase and such data only start to make sense once they have been collated and after appropriate calculation methods have been applied. However, not everyone can imagine the complicated patterns used in order to present results in the form of individual values. It is faster and easier to read the information when it is presented in graphical form. The ability to prepare a visual

representation of results is the fastest way to communicate vital information to others [37]. Presenting urban data graphically to residents can strengthen existing methods of social engagement and contribute to the development of new methods as claimed by Kourtit & Nijkamp [2]. The research also seeks to develop a new measure for socio-economic development which is a challenge. Stiglitz, Fitoussi and Durand point out that new measures are needed to help protect people from possible shocks, restore security and confidence in anti-crisis policies [38]. It therefore also supports the cooperation between the citizens and the public administration is important in determining the direction of the city's development as a whole.

6. Conclusions

The analysis conducted for this paper on the comparison of existing city dashboard solutions is subjective, which constitutes a limitation of the conducted research. Other limitations include the linear ordering method itself, the selection of variables and cities for the survey. However, carrying out the above comparison and the dashboard design work for the City's Fundamental Power Index led to an important conclusion regarding the city dashboards under consideration. Namely, irrespective of the need to meet substantive and formal requirements in the construction of indicators and indices, the application of good practices of visualisation design (Table 2) is an important condition in order for visualisations to be attractive and comprehensible. However, this condition can be insufficient from the perspective of the audience or even negatively impact the transparency and willingness to explore the data made available. Those who design dashboards also need to adapt them to the needs and capabilities of a specific audience. Finally, the measures of data selected for visualisation should be consistent within a single chart or map and offer no opportunities to manipulate the user.

The visualisation of the City's Fundamental Power Index presented in this paper can help improve the competitiveness of a city on a local and international levels. The designed Index combines three key development concepts of a sustainable, smart and resilient city. The visualisation of the author's Index values makes it possible to assess a city's level of development in an integrated and multidimensional way. Additionally, it is possible to identify areas where corrective actions need to be taken or to which attention should be paid in the decision-making process. The use of Business Intelligence technology also has an impact on building digital twins, which are the future of modern cities [39]. As the Index considers key development factors, it is also a tool that can be used to construct a long- and short-term city development strategy. It can also be used by different cities in subsequent years to examine the results of strategic management in the area of the implementation of sustainable, smart and resilient development policy.

The direction of future research depends on the possibility of an actual implementation of the author's Index and corresponding dashboards by local public administrations. Additionally, in the future, it is planned to thoroughly explore user-centered design methodologies and usability heuristics to ensure that dashboards are tailored to the needs and capabilities of a specific audience, taking into account real-time and historical data, organizing them logically and thematically. These activities will have the potential to contribute to the use of effective visualizations to convey content across various platforms and media, improving the overall communication of important information to decision-makers and the local community. The conviction that it is possible and necessary to search for and apply modern tools in the decision-making process as well as the need to continuously improve computational methods in order to make the Index widely used both nationally and internationally remain the main premises of the future research. The said juxtaposition of three city development concepts into a single indicator represents an innovative solution while at the same time creating a new perspective on managing the development of contemporary cities.

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