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LINKED OPEN DATA CONCEPT IN PUBLIC INSTITUTIONS – LOWER SILESIA (POLAND) CASE STUDY

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Purpose: The aim of the article is to review the level of advancement of linked open data (LOD) concept in public institutions, based on the example of Lower Silesia (Poland) organizations. Moreover, this paper considers the level of advancement of Lower Silesia institutions on the famous Tim Berners Lee's scale and compares the obtained results.
Design/methodology/approach: case study of important public institutions of Lower Silesia region, and the assessment of LOD concept advancement, based on 5-star Tim Berners Lee's scale an short expert interviews.
Findings: We can observe considerable interest and willingness to create a network of linked open data, which is visible in the growth of the number of data sets and the ever-expanding structure of the LOD cloud. Implementation of LOD in public institutions can be really helpful in management and decision-making processes. Public entities in Lower Silesia (Poland) should continue to develop their network to reach the highest level of advancement of LOD concept, especially in the context of integration with other data sets.
Research limitations/implications: The limitation of the research was the fact that not all public institutions are still familiar with the concept of linked open data, or do not use it to its full extent.
Practical implications: In the context of public institutions, LOD can play a key role in improving transparency, efficiency, and data-driven decision-making. Users can freely access information that is crucial to them and use it for interesting social or commercial projects, as well as individual ones.
Social implications: The practical implementation of LOD is also related to its social impact, everything depends on the type of data that is made available to users. Very often, they are related to administration, public transport, budget management of smaller and larger communities or health care, what can really contribute to improving the quality of life.
Originality/value: For the first time, the level of advancement of the linked open data concept in Polish public institutions was evaluated, which may improve the results in institutions already using this idea but also encourage them to develop the network of linked data resources.
Keywords: linked open data, management, decision making, big data, data analysis, public institutions, semantic web.
Category of the paper: research paper, case study.

1. Introduction

The concept of Linked Open Data (LOD) is one of the most practical and useful forms of organizing and publishing data. This approach consists in sharing data in an open and linked way, which allows them to be analyzed by public institutions, citizens, and the private sector. The practical implementation of LOD in public administration can lead to increased data credibility and transparency, support for the decision-making process, improvement of the quality of public services and better management of these entities, even in crisis situations.

The article covers key theoretical aspects and practical use of Linked Open Data in public institutions, especially on the example of Polish Lower Silesia region. Technological and organizational aspects will be considered, as well as an analysis of case studies from Poland, aimed at assessing the level of advancement in sharing data in an open and linked way. This study is based on rich literature on the subject, considering scientific research, government reports and legal regulations. The aim of the article is to review the level of advancement of linked open data (LOD) concept in public institutions, especially in the context of the possibility of using it in management and decision-making process based on the example of Lower Silesia (Poland) organizations. This research is also a case study of what kind of open data is available and what can be used by users: citizens, commercial companies, and public organizations. Moreover, this work places the level of advancement of Lower Silesia institutions on the famous Tim Berners Lee's scale and compares the obtained results. For the first time, the level of advancement of the linked open data concept in Polish public institutions was evaluated, which may improve the results in institutions already using this idea but also encourage them to develop the network of linked data resources.

According to the Ministry of Digital Affairs (Karpowicz, 2019), Polish government have set the directions for implementing the policy for opening data by 2027 and indicated the necessary actions to be taken. Within this framework "The Act on Open Data and Reuse of Public Sector Information and the Data Opening Program for 2021-2027" was established. The Program covers key issues in the field of sharing and managing data. It is addressed to government administration bodies, units subordinate to them or supervised by them, and the President of the Central Statistical Office. Additionally, it can also be implemented by other entities that create or store data, in particular local government units or private entities.

The specific objectives of the program are:

- increasing the availability of data on the Dane.gov.pl portal, including those made available via API,
- improving the interoperability and quality of data,
- increasing the use and exchange of data,
- stimulating the market for the reuse of cultural resources and scientific data,
- cooperation with national and international data stakeholders,

- raising the knowledge and skills of public administration employees in the area of opening and managing data and increasing public awareness of the potential of open data.

Unfortunately, on government websites and in case of commercial research it is difficult to find even the first attempts to assess the effectiveness of this program, in particular answers to questions what is the level of advancement of local public institutions in implementing the LOD concept? How is this data used – in what kind of projects or processes it can be helpful (especially is it similar like European or global examples of application)? Finally, what kind of barriers and challenges appear related to the implementation of the program? This knowledge gap motivated the author to undertake preliminary research on the example of Lower Silesia in order to assess the level of advancement in the use of the LOD concept in this region and to answer the research questions. In the future, comparisons with other entities from other regions and analysis of a larger number of nationwide projects should be planned, especially in 2027 to assess the effectiveness of this regulation.

The article consists of 5 chapters: introduction, literature review, where the current state of knowledge and key concepts are defined, examples of applications of European and global LOD concepts in decision-making and management, Lower Silesia (Poland) case study, where the research methods and results are presented, and the summary, where the research results and barriers, challenges and potential benefits of using LOD are discussed.

2. Literature review and basic terms related to Linked Open Data

The foundation of the Linked Open Data concept was presented in the publication of Sir Tim Berners-Lee (Berners-Lee, 2006), who proposed a completely innovative way of linking resources on the Internet - instead of a network of related documents (e.g. html files), he pointed to the need to create a semantic network of objects that, thanks to their connections, will give the user access to larger sets of information about the object of his investigations.

However, linked data term is different from linked open data, which is often confused and sometimes even unintentionally equivalently used. According to Ontotext analytic company (Yankulov, 2025) “Linked Data is one of the core pillars of the Semantic Web, also known as the Web of Data”. The Semantic Web should be not understandable only to humans, but also to machines, so data should be published in a unique way. Because of that, it is possible to create and continuously expand the network of connections between data on the Web of Data, as well as to create ontologies and semantic dictionaries of specific business sectors and industries.

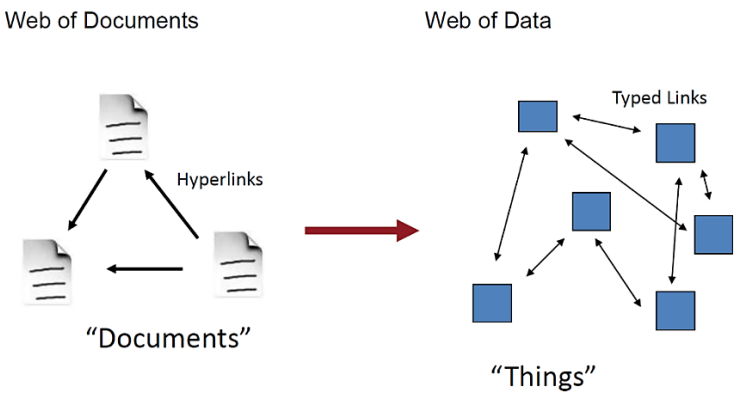

Figure 1. Semantic Web, transformation from web of documents to web of data.
Source: Fensel, 2013, slide 15.

In 2006, Tim Berners-Lee introduced four principles of creating linked data, which include:

1. using URIs (Uniform Resource Identifier) to identify resources on the Web,
2. sharing data in open formats such as RDF (Resource Description Framework), which allows us to describe a Web resource as a triplet: subject, predicate, and object. Moreover, because of the structure, it helps to create dictionaries and ontologies of Web resources,
3. using SPARQL standards for queries,
4. creating relationships between data sets to enrich informational context.

While in the case of open data, it's not necessary to link them for reuse, further distribution or any other business purpose, they can be just open and available to interested stakeholders. That's why linked open data is such a useful concept and very powerful combination of two approaches mentioned before, because it uses both open and linked sources at the same time and it's available under free licenses (e.g. Creative Commons).

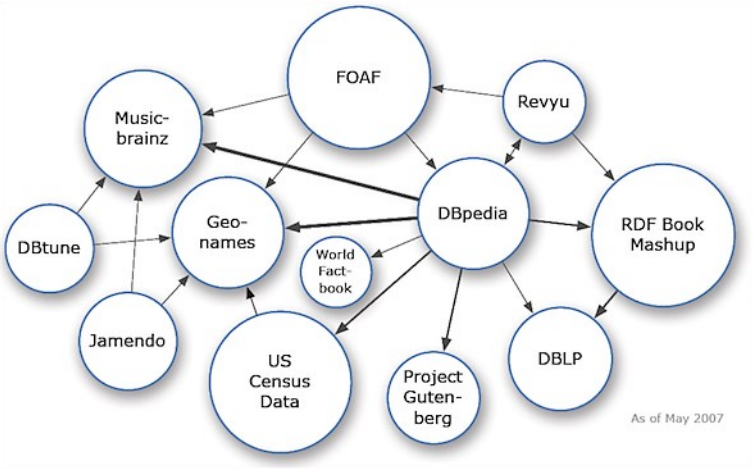

Figure 2. The linked open data cloud in May 2007 – very early stage of LOD concept.
Source: lod-cloud.net, 2025.

The most famous practical example of the LOD concept is DBpedia – a crowdsourcing database created in 2007 based on open, linked Wikipedia resources, allowing users to define queries and find connections between specific objects and other sources on the Web. The latest version of DBpedia (DBpedia, 2025):

- contains factual data from articles and infoboxes of the English Wikipedia Language Edition (WPLE),
- is enriched with labels and abstracts from the largest Wikipedia Language Editions,
- is enriched with rdf: type statements to several ontologies,
- contains approx. 900 million RDF triples (Jan 2021) but is steadily growing.

Almost at once, in 2010, after the success of DBpedia, this concept was adopted by other entities, e.g. Best Buy, BBC World Cup site, Google, Facebook and Flipboard. In 2011 Google, Microsoft, and Yahoo have even announced the joint vocabulary initiative for common meaning to data on the web which was called schema.org (Fox, 2011). In another publication (Bizer, Heath, Berners-Lee, 2009) the importance of linked open data in building interoperable information systems and it's growing role in public administration were strongly emphasized. In May 2012, Google's Knowledge Graphs were introduced – based on rooted in public sources such as Freebase, Wikipedia and the CIA World Factbook (Singhal, 2012) covering places, people, companies, businesses and more. By May 2020 Google has announced it contains approximately 5 billion objects, as well as more than 500 billion facts about and relationships between these different objects (Sullivan, 2020).

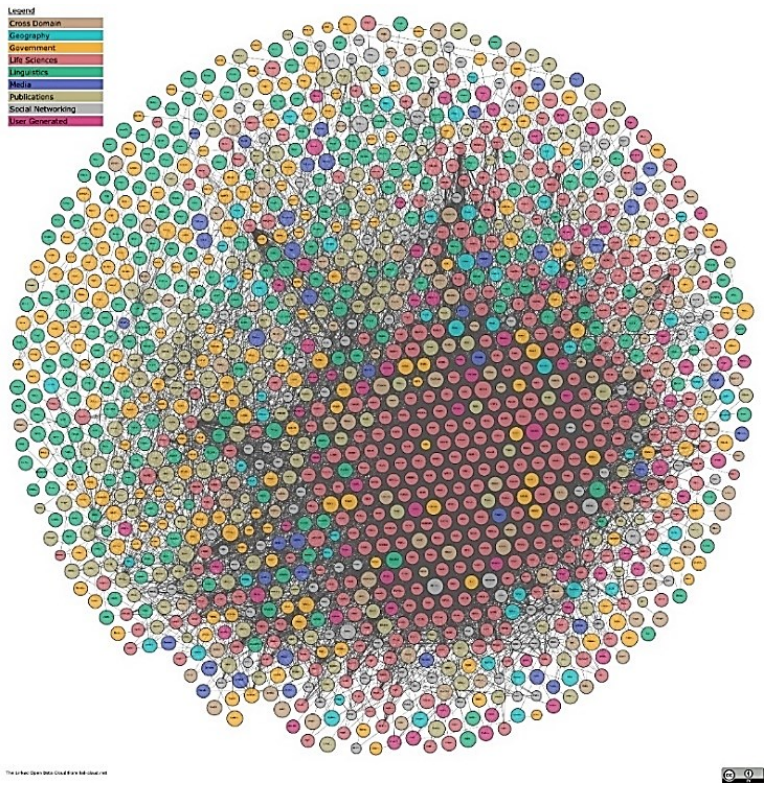

Figure 3. Current state of linked open data network.

Source: lod-cloud.net, 2025.

Today, there is still a need to take care of the form of sharing linked open data and its quality. This data should be free for users and made available in the form of linked, editable data sets that can be processed using open licenses. The number of such data sets, as shown in the figure below (Figure 4), is still growing, but these are often thematically related, hermetic graphs, often strongly related to the specifics of a given industry. On the one hand, this allows them to be used for research, strongly embedded in a given type of business, however, there is potential for further expansion of connections, so as to find integration points between different areas of business or science. As Hitzler mentioned (Hitzler, 2021) "recent activities around knowledge graphs are fueled by the strong industrial use cases and their demonstrated or perceived added value".

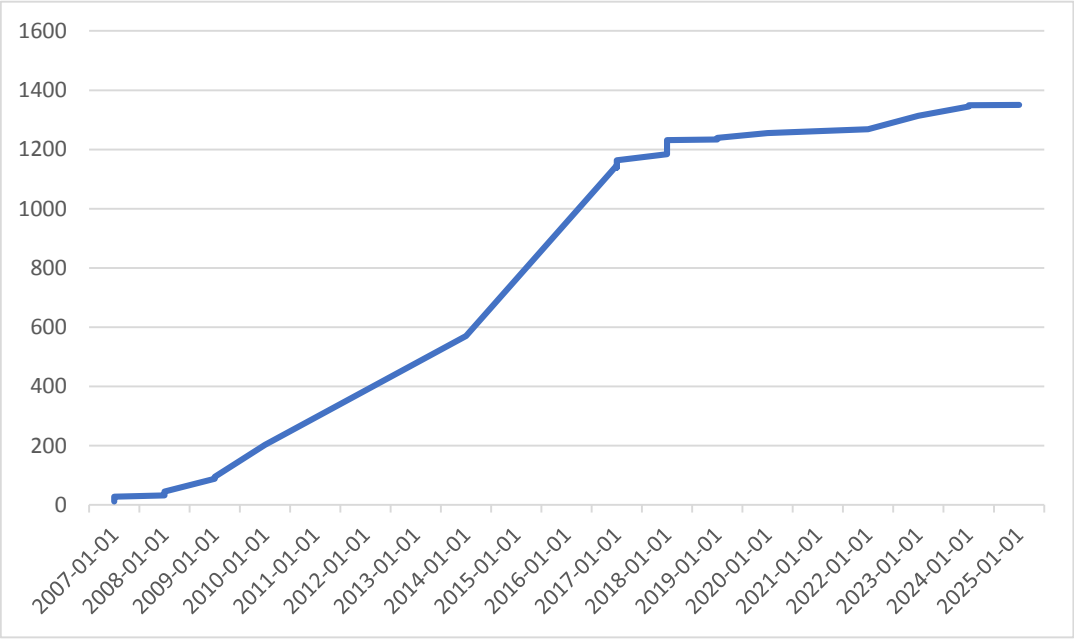

Figure 4. Number of datasets in the Linked Open Data Cloud over time.

Source: own elaboration, based on The Linked Open Data Cloud, (2025).

To sum up literature review, we can observe considerable interest and willingness to create a network of linked open data, which is visible in the growth of the number of data sets and the ever-expanding structure of the LOD cloud. However, there are not too many publications on how this data is published, whether it meets all the assumptions about its availability, and therefore how useful it is in the decision-making process and in the management of the indicated entities. It is also interesting to answer the question whether there are challenges and barriers in this area. In addition, the potential benefits of implementing a linked open data policy will also be discussed.

3. The usage of linked open data in public institutions – decision-making and management practices

The concept of linked open data in public institutions is widely used all over the world, both in local and global administrations. Publishing data in the form of LOD can improve the management of public resources, increase citizens' access to information, support the development of innovative services and, in general, improve the quality of life. Therefore, it is not surprising that there is a desire to use this idea, especially in the process of making key decisions for society and broadly understood resource and organizational management. The application can be very varied, starting from government administration and creating open data systems, through healthcare: epidemiological analysis and prediction of health threats or transport management - optimizing road traffic based on data generated in real time. The author would like to cite several selected examples of global applications of the LOD concept in public institutions supporting the management and decision-making process, although there are many more of them, and thanks to the constantly expanding network of dataset connections, new, interesting initiatives are constantly emerging.

Among the particularly interesting initiatives we can certainly mention:

1) **EU Open Data Portal** - provides information from different European Union agencies and Member States in a format compliant with the Linked Open Data principles. Recently The Open Data Maturity (ODM) 2024 report (Page et al., 2024) has been announced, which is an assessment of the progress of European countries in promoting and facilitating the availability and reuse of public sector information. The four dimensions of open data maturity were taken into consideration:
   - the level of development of national policies promoting open data,
   - the features and data made available on national data portals,
   - the quality of the metadata on national data portals, and
   - initiatives to monitor the reuse and impact of open data.

   The following chart allows us to find out the composite linked open data maturity level, which countries are beginners, followers, fast-trackers and trend-setters in this field:

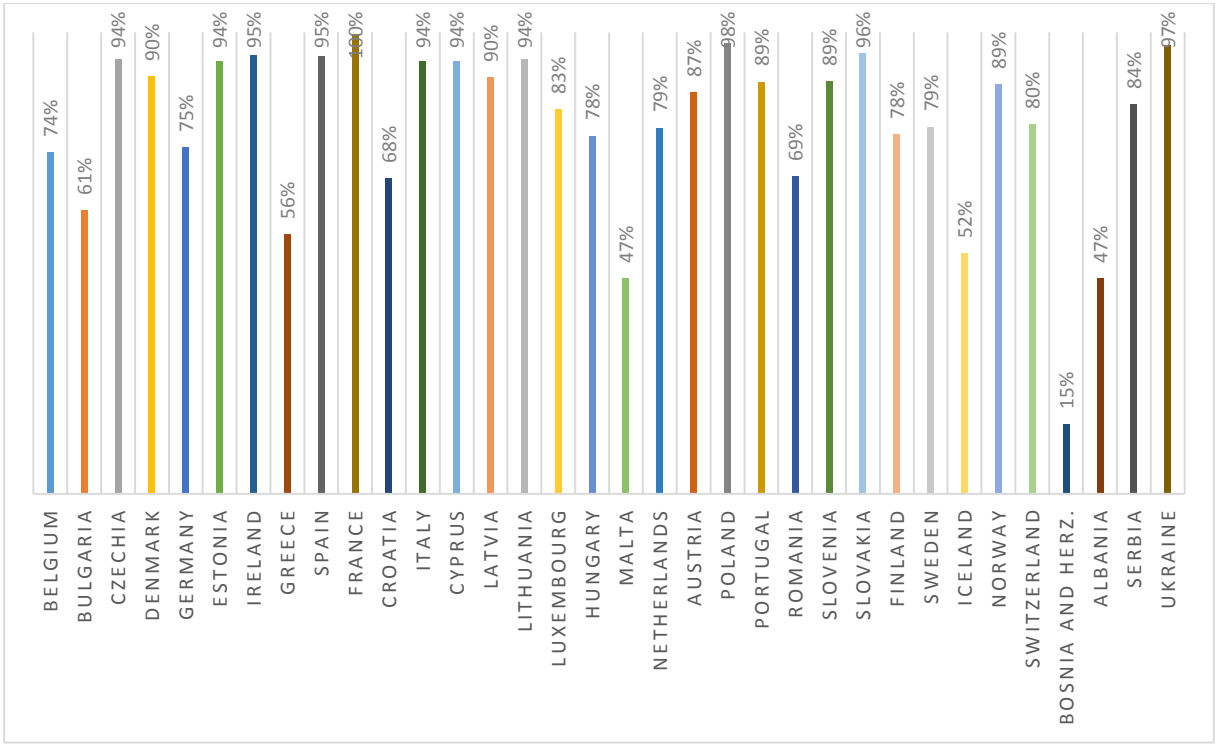

Figure 5. Composite open data maturity level among EU countries.

Source: own elaboration, based on Page et al., 2024.

Moreover, portal holds presents economic statistics, geographic data, and data related to environmental policies. It supports legislative processes by providing integrated information on the impact of regulations. Access to data by start-ups creating transport or environmental applications is also available to users.

2) **Data.gov in the USA and European countries releases** - Government Data.gov portals provide data from thousands of federal agencies in the United States and many regions/provinces in European countries. The data is published in open formats, which allows easy integration with other data sets. Resources include infrastructure and transportation data to optimize public transport routes, information to support public health decisions, such as analyzing epidemiological data during the COVID-19 pandemic, and advances in the development of tools for citizens to monitor budgets and the impact of government policies on local communities.
3) **World Bank – Atlas of Sustainable Development Goals (SDG)** - The World Bank provides LOD-compliant data to monitor progress towards the Sustainable Development Goals (SDGs). We can follow e.g. details about each country's poverty rate, health and well-being index, quality of life, economic growth, innovation, climate, and progress indicators, supporting decisions of on the allocation of development funds.
4) **INSPIRE – Infrastructure for Spatial Information in Europe** – an EU initiative aimed at making spatial data available in a LOD-compliant format. This data is used in environmental management and spatial planning. It enables monitoring of land use

changes to protect the environment and supports crisis response activities such as flood or forest fire rescue.

5) **OpenCorporates – Linked Open Company Data for Anti-Corruption Institutions** - world's largest open database of company information. It is used by governments and public organizations to battle economic crimes. Useful tool to monitor public transactions and detect conflicts of interest but also analyze links between economic entities in money laundering investigations.
6) **FAO** – according to Food and Agriculture Organization of the United Nations (AGROVOC, 2025) it's "a Linked Open Data set about agriculture available for public use and facilitates access and visibility of data across domains and languages". It enables standardization of agricultural data, dictionaries and their integration with climate data. Moreover, it supports decisions in the field of food security and natural resources management.

These examples prove that Linked Open Data usage in public institutions can find application not only in administration and planning, but also in sustainable development, public health and environmental protection, supporting innovative decisions and the management of public services.

4. Lower Silesia (Poland) public institutions case study – research methods and the results

According to The Open Data Maturity (ODM) 2024 report (Page et al., 2024) Poland is one of the countries that is a trend-setter of European open data maturity level (Figure 5). The use of Linked Open Data (LOD) in Lower Silesia is an important element in the development of the information society and in sharing public data. The LOD initiative, widely promoted (as mentioned earlier) in Europe, combines open data with network technologies, enabling the creation of linked and easily accessible information resources. In 2012 (Klink et al., 2012), the "Strategy for the Development of the Information Society in Lower Silesia until 2020" was developed, the aim of which was, among others, to promote open standards and data interoperability. This document, prepared in cooperation between the Marshal's Office of the Lower Silesian Voivodeship and the Wroclaw University of Science and Technology, emphasized the importance of open data in building a modern knowledge-based economy. An example of the practical use of LOD is a game project based on data on the Wroclaw city budget, entitled "Media 3.0 SAP", which took third place in the first government hackathon competition in 2016, based on open linked data. It is worth mentioning that the first place was taken by the "Fingers" team for an application used to handle matters in public offices faster. The main objective of the research was to assess the level of advancement of websites

of public institutions in one of the dynamically developing regions of Poland – Lower Silesia – and in particular how they implement the concept of not only open data but also linked data. The research has a preliminary nature and lasts for two months from November to December 2024. The adopted methodology included case studies of important public institutions, and when the assessment was difficult due to technical reasons, it was decided to conduct short expert interviews with website administrators or representatives of the indicated entities. The choice of research methods was not accidental, both case study analysis and expert interviews are qualitative methods that allow for a detailed understanding of procedures and relationships within the studied object. These methods allow for taking into account the broad background of the studied phenomena, including social or organizational factors, and in the event of difficulties in assessment, they allow for asking questions that specify what a given phenomenon looks like in the research entity. These methods are also helpful to analyze unique use cases, if the studied phenomenon is unusual or exceptional, the case study allows for their thorough exploration, which is why they are often used, for example, in the analysis of entities implementing innovative technologies or technological concepts, as in the presented article. Moreover, the case study allows for the formulation of new hypotheses, especially in preliminary or pilot research, which can be verified in further extended studies on a larger number of entities. Unstructured interviews were used here, because it allowed for a short verification (when doubts appeared) whether the selected institutions meet the criteria of the LOD concept scale. Finally, the analysis of the content on the websites of selected public institutions in Lower Silesia will allow for the assessment of the level of advancement of the Linked Open Data idea. Several dozen examples were analyzed, but the article presents the most interesting ones, on which it was possible to collect and confirm the most reliable data. The need to conduct additional interviews only arose when the websites of selected institutions were very extensive and contained large data resources. The difficulty was mainly in assessing whether the website met the 5-star criteria on the Tim Berners-Lee scale. Website administrators or representatives of the indicated entities consisted of asking whether the posted data had links to other network resources, in other words whether they met the last criterion on the aforementioned scale. The answers placed the websites in the hierarchy of advancement in the application of the linked open data concept. In some cases, interviews were not necessary, because the structure of the website allowed us to assess the level of advancement of the entity's data publication. After selecting the examples, they were rated using the famous 5-star Tim Berners-Lee scale (Berners-Lee, 2006) which is as follows:

Table 1.
Tim Berners Lee's 5-star linked open data scale

Scale	Explanation
1*	data should be accessible, in any form, under any open license, e.g. Creative Commons on the Web
2*	data should be accessible in a structured form, e.g. as a spreadsheet instead of its image or scan
3*	data should be accessible in an open format (e.g. CVS instead of Excel file), so data format is independent of the software vendor
4*	data should be marked with URIs and/or RDF description to facilitate identification and unambiguous reference to resources
5*	data should be linked to other data to provide context and enrich its value, creation of global network of information is possible

Source: Berners-Lee, 2006.

The assessment of websites of main public institutions in Lower Silesia in terms of Tim Berners-Lee's five-star scale requires an analysis of the availability and format of the data they provide. The higher the level on the scale, the more useful and easier the data is to reuse, also in the context of integration with other data sources. The results of the analysis and research are as follows:

1) **Wroclaw City Office website (bip.um.wroc.pl) –** website of the capital of Lower Silesia region in Poland – Wroclaw, provides a variety of public data, such as the city budget, spatial development plans, and demographic statistics. This data is often available in PDF or XLS formats, which ensures machine readability. However, there is no information about the use of open standards such as RDF or SPARQL, or about connections with other data sets. Additional interviews with experts did not confirm this information either. Therefore, this site can be rated 3 stars, as it provides data in a non-proprietary format, but does not meet the requirements of higher levels of scale.
2) **Marshal's Office of the Lower Silesian Voivodeship (bip.dolnyslask.pl) –** the official website of the Marshal's Office provides various documents and data on the region, such as development strategies, reports, and information on EU projects. This data is provided in formats such as PDF or DOC, which ensure machine readability. However, as in the previous case, there is no information on the use of open standards or on links to other data sets. Despite additional interviews, this information could not be confirmed. Therefore, this website can be rated 3 stars.
3) **Lower Silesia Geoportal (geoportal.dolnyslask.pl)** – portal provides geographic data in formats such as SHP or GML, which are machine-readable and non-proprietary. However, there is no information about the use of standards such as RDF or SPARQL and about connections with other data sets. Therefore, this portal can be rated 3 stars.
4) **Lower Silesian Voivodeship Office (www.gov.pl/web/dolnoslaski-uw)** – The website of the Lower Silesian Voivodeship Office provides various public data and information, such as press releases, statistics, and information on government programs implemented in Lower Silesia. This data is available in formats such as PDF or DOC, which ensures its machine readability. However, additional interviews did not confirm the use of open

standards and about connections to other data sets. Therefore, this site can be rated 3 stars.

5) **Wroclaw Open Data (www.wroclaw.pl/open-data)** – portal enables all interested stakeholders, including Wroclaw residents, to quickly and easily access public information collected by the Wroclaw City Office and other city units. The platform presents budget data, spatial, demographic, educational, cultural, environmental, social and communication data. Information is provided in formats such as WMS, GML, XLS, CSV, SHP, or DOC, which ensures machine readability. Portal uses standards such as RDF and provides links to other data sets or their graphical visualizations. Therefore, this site can be rated 5 stars. Unfortunately, the website is available only in Polish version.
6) **Bridge of knowledge (mostwiedzy.pl**) – the platform has been designed to meet all five levels of data openness. Resources about research infrastructure and scientific activity all over the country, also in Lower Silesia, are available to scientists, entrepreneurs and society in an open, simple and transparent form. It provides data in open, machine-readable formats, using standards such as RDF, and provides links to other data sets, allowing the full potential of Linked Open Data to be used. As such, the platform deserves a 5-star rating.
7) **Open Data Portal (dane.gov.pl)** – nationwide portal where institutions from Poland, including Lower Silesia region, share their data. The website provides access to data in open and machine-readable formats and also promotes their reuse (its marked by URIs). According to Data Governance Act (DGA) information point on the website – conditions of reuse of data are laid down individually in the course of processing a request and are adjusted to a given case, type of data requested, preferred way of accessing data, etc. However, there is no information about direct connections of data with other data sets via links. Therefore, this portal can be rated 4 stars.

Table 2.
Summary of research results

Name of website/Tim Berners Lee's scale	**1***	**2***	**3***	**4***	**5***
Wroclaw City Office website	X	X	X		
Marshal's Office of the Lower Silesian Voivodeship	X	X	X		
Lower Silesia Geoportal	X	X	X		
Lower Silesian Voivodeship Office	X	X	X		
Wroclaw Open Data	X	X	X	X	X
Bridge of knowledge	X	X	X	X	X
Open Data Portal	X	X	X	X	
				Average value:	**3,71**

Source: own elaboration.

5. Conclusions – potential benefits, challenges and barriers

The main aim of the article was to review the level of advancement in the use of linked open data (LOD) by public institutions, especially in the context of the possibility of using them in management and decision-making process based on the example of Lower Silesia (Poland) organizations. Thanks to the case study of selected institutions for which it was possible to verify the relevant data and conduct expert interviews, it turned out that the average level of advancement is equal to 3,71 on the 5-point Tim Berners-Lee scale. This proves a relatively high level of development of the linked open data concept of the websites of public institutions in Lower Silesia. However, it was noticed that in many cases there is still no visible connection between the data published on the websites of such organizations and other resources on the Web, which is why only 2 websites achieved the maximum score. Of course, this may be due to the fact that the research was preliminary. In the future, in order to deepen the analysis, a comparison of entities from different regions of Poland is planned, and perhaps also international research using surveys. On the other hand, the concept has been known for over 20 years now, and the sets of open linked data are still expanding (Figure 4). Moreover only 2 years left to the end of government "The Act on Open Data and Reuse of Public Sector Information and the Data Opening Program for 2021-2027", so we should expect the first effects. Therefore, it can be concluded that some public institutions should consider how to achieve a better result, especially when it comes to data integration and its practical usage. Of course, this may involve numerous challenges and barriers that they will have to overcome. It seems crucial to increase the awareness of employees of public institutions of the benefits of the concept of linked open data. Even during short expert interviews, it was not so obvious to institutions' representatives that LOD allows the use of data from various sources, building a network of related data, their integration and interoperability, as well as standardization of formats, which facilitates machine processing. Additionally, it can contribute to fulfilling the mission of such entities, as data becomes more accessible and transparent to citizens. Standardizing data, and therefore publishing it according to Tim Berner-Lee's principles mentioned earlier, allows for easier integration of data from different sources and ensures their semantic compatibility. Problems may arise from differences in data modeling, which require data mapping or the way ontologies are created. Another challenge is the fact that in many cases the data sets are very hermetic and thematically related, so the expansion of linked open data and integration of many sources can create more comprehensive, enriched resources. An additional argument is the flood of information on the Web – it's obvious that we live in the era of big data, so linked open data concept is the chance to find interesting content more easily and apply an appropriate licensing policy, which can definitely improve the quality of scientific research, analytical, decision-making and management processes. LOD concept in the case of public institutions is also the chance to cooperate with business and jointly develop innovative

ideas. This is shown by the example of Hackathons. Companies can use public data under appropriate licenses (e.g. Creative Commons) to build applications such as semantic search engines, intelligent recommendation systems or data visualization platforms or new business models. Moreover, for organizations themselves, the use of linked open data can be crucial for organizing internal or external information and knowledge management. Technical limitations may be a significant barrier in the case of public institutions, especially in the context of preparing and sharing data in the right formats. Software supporting LOD must be compatible with semantic web technologies, enabling easy connection, processing and sharing of data. Interoperability between different systems may require support for different versions of standards and APIs. The software must support key LOD standards, such as RDF, SPARQL, OWL, JSON-LD. Not all systems support the full set of these standards, which can cause difficulties in data exchange. The software should be able to convert between different formats (e.g. RDF to CSV, XML, or JSON-LD) for integration with other applications. In addition, LOD standards evolve (e.g. new versions of OWL or SPARQL), so the software must be regularly updated. Older systems may not support newer features, which leads to compatibility issues in the LOD ecosystem. Small budgets allocated for such projects can be also quite problematic. Developing guidelines for the appropriate publication of data, especially in the context of protecting their privacy and security, may also be a challenge. Privacy protection, especially in the case of personal data, requires the use of anonymization and access control mechanisms and appropriate encryption. In each case, an individual decision should be made about the possibility of sharing, because once something is shared, it will remain so, which can significantly affect the reputation of the entity. Therefore, it seems necessary to invest time and financial resources in further training or workshops in public institutions to raise awareness of the benefits of LOD, to develop technical competences and consistent standards to facilitate the implementation of these practices. It is hoped that this research will help public organizations to assess their own level of advancement in implementing the linked open data concept and to take corrective actions if it’s necessary.

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