Online Journal of Applied Knowledge Management

A Publication of the International Institute for Applied Knowledge Management

Volume 13, Issue 2, 2025

From transparency to innovation: The role of open government data

Jędrzej Wieczorkowski, SGH Warsaw School of Economics, Poland,
jedrzej.wieczorkowski@sgh.waw.pl

Ilona Pawełoszek, Czestochowa University of Technology, Poland,
ilona.paweloszek@pcz.pl

Abstract

Open Government Data (OGD) has become a key driver of transparency, innovation, and sustainable development. By making public sector information accessible, OGD fosters economic growth, improves public services, and strengthens democratic governance. This paper explores the role of OGD in promoting innovation and advancing the Sustainable Development Goals (SDGs), particularly in urban planning, environmental protection, and public health. It also examines challenges in data accessibility, interoperability, and usability, highlighting the need for standardized formats and open APIs. A case study of the JakDojade transport planning application demonstrates how OGD can enhance smart mobility, reduce environmental impact, and create business opportunities. However, limitations in data availability and licensing practices hinder full utilization. This paper calls for improved data-sharing policies and IT infrastructure to maximize the societal benefits of open data.

Keywords: Open data, open government data, public sector information, linked data, public transport planner, innovativeness, sustainability.

Introduction

Public sector institutions generate vast amounts of data, known as Public Sector Information (PSI). This includes spatial development info, demographic statistics, weather forecasts, data on publicly funded projects, and digitized library books. Collecting, processing, and publishing this data demands considerable resources and energy, highlighting the investment needed for sustainable PSI management.

Much public sector data is open. Open Government Data (OGD) means that public information should be accessible to all. Discussions on data openness began in the 1940s when sociologist Robert King Merton advocated for open scientific data, establishing transparency and knowledge sharing (Stephan, 2004). The International Geophysical Year (July 1957 - December 1958) built on Merton's ideas, promoting international collaboration and the exchange of scientific data (Buedeler, 1957). The term "open data" first appeared in a 1995 report by an American scientific agency on geophysical and environmental data, which stressed access and collaboration (Stewart, 2018). OGD has evolved significantly over the years, achieving key milestones.

With the rise of the digital era and the knowledge-based economy, opportunities to create and publish open data have significantly increased. From a technical perspective, the Open Data

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20
Accepting Editor: Meir Russ

initiative emphasizes making data freely accessible in a machine-readable format, typically accompanied by an open license that allows for reuse and redistribution. In this context, the open data initiative aligns with the principles of the circular economy and sustainable development. Open data supports the Sustainable Development Goals in two keyways: by reusing data that has already required energy, resources, and research effort to produce, and by publishing information that remains valuable for economic and social development, thereby contributing to sustainability in the digital economy (Niankara, 2022).

In this paper, we examined how open data can accelerate the creation of a more sustainable socio-economic ecosystem, influence the lives of residents, and impact the natural environment. These aspects include data preparation, publication platforms, visualization, exploration, and mapping. The open data movement is not driven by a single founder; rather, it encompasses a community of individuals and organizations that believe in the value of open information and data. This paper also contributes to the literature by proposing a classification of cooperation models (e.g., Government to Business to Customer (G2B2C), Government to NGO to Citizen (G2N2C)) that reflect different pathways of OGD reuse in business and civic contexts. Therefore, it also serves as a call to action for governments, businesses, and citizens to embrace the potential of open data.

The Idea of OGD and Cooperation Models

The idea of OGD encompasses concepts such as open data, open government, and civil society. A vital aspect is data openness. The Public Domain Manifesto (2010) stated that the structural Public Domain consists of society's shared knowledge, culture, and resources, used without copyright restrictions. It encompasses information accessible to all, where ideas, history, and creativity are shared freely due to the absence of copyright or creators' dedication to collective benefit. This resource is crucial for forming society's collective knowledge and cultural identity.

According to the Open Knowledge Foundation (2025), the core principles of openness include availability and access, reuse and redistribution, and universal participation. These principles define whether a dataset or resource can truly be considered "open" in a legal and technical sense (OKF, 2025). For true openness, data must be fully accessible at minimal cost (preferably downloadable online) in an easily editable format. Everyone should use, reuse, and share the data for any purpose, commercial or non-commercial. Redistribution may involve mixing with other datasets. Restrictions on use in specific fields (e.g., only for educational purposes) are unacceptable. Thus, both the social and economic aspects of open data usage are essential.

Open government promotes transparency in state activities, leveraging technology to engage citizens in decision-making. It aims to create a knowledge base for policy-setting, enhance integrity, reduce corruption, and build social trust (Curristine & Abbott, 2005). Civil society employs democratic mechanisms for activity and self-regulation without government interference.

Data from the public sector constitutes a distinct category, as they are generated with public funds raised through taxation across society. The state should be required to share this data because its agencies are granted privileges through legal mechanisms that compel citizens, businesses, and other organizations to provide source information (Mayer-Schonberger & Cukier, 2013). Several fundamental arguments support making public sector data accessible: government transparency

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20

Accepting Editor: Meir Russ

(control function), participatory governance (citizens' involvement in decision-making processes), and unlocking social and commercial value (Janssen et al., 2012).

Accessibility considerations can also be categorized differently:

- Private applications, which support individuals' daily lives (e.g., navigation, services);
- Oversight applications, enabling citizens to monitor government actions and support democracy (Sieber & Johnson, 2015);
- Economic applications, which allow businesses to generate new products or services based on OGD.

The commercial value of data arises from its essential role as a key driver of economic development. Access to high-quality, timely information provides a competitive advantage, especially given current advances in big data (Janssen & Kuk, 2016) and AI-driven analytics (Costa Climent et al., 2024). A defining feature of OGD is the reuse of data for purposes beyond its original collection intent. The data user may be a citizen, a business entity, or another organization. The administrative body then becomes a passive participant in the process, providing data that is gathered at the initiative of its subsequent user (Begany et al., 2021). It is possible to terminate the entire inter-organizational data flow process at the recipient level. For example, in the Government-to-Citizen (G2C) model, individuals may use public data to meet personal needs. In the Government-to-Business (G2B) model, companies can use public data for internal analysis or product development. Often, businesses reuse such data as intermediaries, building new services on top of publicly provided information (Lassinantti et al., 2019; Pizzamiglio, 2024). Building on these categories, Government to Business to Business (G2B2B) and G2B2C models describe how public data can enable downstream transactions in business ecosystems. While G2B focuses on data flow, B2B and B2C describe commercial interactions enabled by such data. Products built on OGD may also integrate information from non-public sources (Jetzek et al., 2014).

While traditional cooperation models in public-sector data reuse focus on G2C, G2B, and Government-to-Government (G2G) interactions, this paper introduces an extended typology that includes indirect and multi-actor flows involving non-governmental organizations (NGOs). Models such as G2N2C and Government to NGO to Business (G2N2B) reflect the increasing role of civil society organizations in data mediation and co-creation of public value (Brzustewicz et al., 2021; Glavee-Geo et al., 2023). To out knowledge, such classifications have not been explicitly formalized in the OGD literature and therefore constitute a novel conceptual contribution of this study. While prior studies have addressed various forms of cross-sector collaboration (e.g., Glavee-Geo et al., 2023), our typology extends these models by focusing on the specific role of NGOs in mediating public data flows.

Table 1 synthesizes the proposed typology of OGD-based collaboration models, including both traditional (e.g., G2C, G2B) and extended forms involving civil society actors (e.g., G2N2C, G2N2B). It highlights their key characteristics, data usage roles, and practical applications across public, private, and NGO domains.

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20
Accepting Editor: Meir Russ

Table 1. Typology of OGD-Based Business and Service Models

Model Type	Description	OGD Role	Example/Application
G2C (Government to Citizen)	Citizens use open government data for personal benefit (e.g., checking air quality, public transport)	Direct use by end users	Air quality alerts, COVID case maps, and local budget browsers
G2B (Government to Business)	Businesses use OGD internally to inform operations or strategy (e.g., market analysis)	Internal decision-making resource	Retail site location planning based on demographic data
G2B2C (Government to Business to Consumer)	Businesses build consumer-facing services based on OGD (e.g., transport apps like JakDojade)	Core input for consumer service delivery	JakDojade app (public transport), property price maps
G2B2B (Government to Business to Business)	Businesses use OGD to create services for other businesses (e.g., supply chain analytics)	Value-added layer for B2B services	Fleet optimization tools using traffic or infrastructure data
G2N2C (Government to NGO to Citizen)	NGOs process and redistribute OGD to inform or support citizens (e.g., watchdog portals)	Public service or advocacy enhancement	NGO platforms tracking public procurement or education
G2N2B (Government to NGO to Business)	NGOs curate OGD and provide it to businesses for specific sectors (e.g., environmental risk data)	Thematic filtering and redistribution	Sectoral reports built from public economic or climate data

From a sustainable development perspective, NGOs play a crucial role in expanding data use to underserved communities and underrepresented topics. These actors may operate in structures similar to those outlined above, including G2N2B, G2N2N, or G2N2C pathways. In contrast to business-centric models, these often involve non-commercial purposes, such as watchdog activities or educational services built on processed OGD.

Open Data for Sustainable Development Goals

The Sustainable Development Goals (SDGs) are 17 objectives set by the United Nations (UN) to tackle social, economic, and environmental challenges by 2030. They address issues like poverty, climate action, and gender equality. The three pillars of sustainable development highlight the interconnectedness of social, economic, and environmental dimensions (UN, 2015), as progress in

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20

Accepting Editor: Meir Russ

one area often relies on the others. The social pillar promotes equity and well-being for all. Economic sustainability focuses on growth and fair resource distribution, while environmental sustainability aims to protect ecosystems and manage resources responsibly for future generations.

Open data supports various SDGs by enhancing democracy through transparency and accountability (Davies et al., 2019). Specifically, it relates to SDG 16, which encompasses peace, justice, and strong institutions. For example, local governments publish open data on plans and expenditures to invite public consultation, enabling residents to suggest improvements. This practice promotes participatory governance by actively involving citizens in decision-making beyond voting, thereby empowering communities to influence decisions that affect them and bridging the gap with those in power.

Publishing open urban data supports Sustainable Development Goal 11 (Sustainable cities and communities) (UN-Habitat, 2020) by enhancing urban planning, transportation, and infrastructure to create inclusive, safe, and sustainable environments. Examples include spatial development plans that help citizens make informed decisions about residence and business locations.

The coronavirus pandemic highlighted the value of open health data. Analysis of symptoms and hospital admissions enabled public health officials to detect infectious disease outbreaks earlier, facilitating faster resource allocation and intervention. Such data also reveal areas with high disease prevalence or limited access to medical services, thereby supporting SDG 3 for good health and well-being (Adams et al., 2022; Niankara, 2022).

Climate action (SDG 13) can be supported by open climate data (Intergovernmental Panel on Climate Change (IPCC), 2021), including greenhouse gas emissions and air quality data. On a global scale, NASA Goddard Institute for Space Studies reports provide datasets spanning decades on temperature, precipitation, sea level, and other climate variables, covering the entire globe. The National Oceanic and Atmospheric Administration (NOAA) offers a wide range of datasets on climate, weather, and oceans, including global land and ocean temperature records, greenhouse gas measurements, and satellite imagery (NOAA, 2023). Collectively, these international initiatives—together with the comprehensive assessments published by the IPCC—form the empirical foundation for understanding climate change science, its impacts, and mitigation strategies.

Responsible institutions also publish regional climate data. The European Environment Agency (EEA) (2025) provided information on environmental indicators, including climate change, for European countries. Similarly, the EPA (2025) offers datasets on greenhouse gas emissions, air quality, and other environmental variables in the United States. Additionally, country-specific institutions, such as the Japan Meteorological Agency (JMA) (2025), provided climate observations and projections for Japan and its surrounding regions. Local climate data collected from sensors and weather stations keep residents informed about air, water, and atmospheric conditions. It is important to note that this data underlies the functionality of mobile applications, enabling users to plan for outdoor activities (Bhandekar et al., 2024).

One of the most impactful areas where OGD supports SDG 16 (Peace, Justice, and Strong Institutions) is public financial transparency. Platforms such as OpenSpending, developed by the Open Knowledge Foundation (2024), allow users to explore and visualize national and municipal

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20
Accepting Editor: Meir Russ

budgets worldwide. When combined with procurement and contract data, these datasets become powerful tools for detecting corruption patterns, monitoring spending efficiency, and promoting civic oversight. Studies have shown that increased fiscal transparency is positively correlated with reduced perception of corruption and improved trust in institutions (Bauhr et al., 2020; Wehner & de Renzio, 2013). The final benefit of open government data is its contribution to education, research, and knowledge sharing (SDG 4). Open data enables researchers and educators to analyze complex interdependencies across demography, environmental change, and economic activity.

While not strictly classified as OGD, open educational platforms such as NAVOICA, developed under the "Polski MOOC" initiative by the Ministry of Education and Science, reflect a broader commitment to openness in the public sector. Managed by the National Information Processing Institute, NAVOICA offers free access to online courses across various fields, thereby supporting inclusive and equitable education (Smyrnova-Trybulska et al., 2021). In parallel, public education datasets — such as enrollment statistics or regional disparities in educational access — enable data-driven analysis and policy-making (Kumari & Dayal, 2025). Together, these initiatives foster innovation in teaching and learning, indirectly enhancing equality and labor market competitiveness. Complementary to platforms like NAVOICA, public-sector datasets play a vital role in achieving the SDGs by enabling innovation and accountability across sectors (UNESCO, 2019). Table 2 summarizes key areas where OGD supports the advancement of selected goals.

By harnessing the power of open data, stakeholders can drive progress across multiple SDGs, promote sustainable development, and create a more equitable and resilient world for future generations. However, it is important to note that the reuse of open data from the public sector is not meeting expected levels (Lassinantti, 2019). This observation raises several important points for consideration. While the PSI is made available to the public, challenges may exist in ensuring its accessibility and raising awareness among potential users. Efforts to improve discoverability and promote understanding of the value of open data could enhance its reuse.

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20

Accepting Editor: Meir Russ

Table 2. Mapping of Open Government Data Contributions to Selected Sustainable Development Goals

SDG	Example of OGD Use	Related Domain	Case/Application
SDG 3 – Good Health and Well-being	COVID-19 dashboards, hospital capacity data, vaccination rates	Public health	OECD COVID-19 Policy Tracker – a portal aggregating national pandemic responses and public health data
SDG 4 – Quality Education	Statistical data on enrollment rates, educational outcomes, and regional disparities (e.g., from GUS or national education portals)	Education and skills	GUS Education Statistics – datasets from Poland's Central Statistical Office and the Ministry of Education
SDG 11 – Sustainable Cities and Communities	Real-time transport schedules, mobility data, and city planning datasets	Urban mobility and infrastructure	JakDojade app – Polish public transport planner using local OGD and GPS data
SDG 13 – Climate Action	Air quality indices, CO_2 emissions data, and climate monitoring platforms	Environmental monitoring and policy	European Environment Agency (EEA) AirBase, NASA GISTEMP, Japan Meteorological Agency (JMA) climate datasets
SDG 16 – Peace, Justice, and Strong Institutions	Budget transparency portals, procurement data, and open legislation platforms	Governance and public accountability	World Bank Open Budgets Portal, OpenSpending – global platforms for visualizing and analyzing public finance data

In some cases, limited open data usage stems from a lack of interoperability and standardized formats among various datasets (Janssen et al., 2012). Utilizing open data in electronic form may necessitate computer literacy, including software and analytical skills. Consequently, potential users might need training or support to effectively utilize open data for their purposes. Capacity-building initiatives focused on data literacy and analytical skills can empower individuals and organizations to make meaningful use of PSI (Davies, 2019; The Data Foundation, 2022).

Open data usability involves collaboration among public sectors, academia, industry, and civil society, fostering innovation and developing PSI-based applications (Zuiderwijk et al., 2021). Engaging stakeholders in co-creation can produce solutions for real-world challenges and enhance open data's value (Veljković et al., 2014). Regulatory frameworks are vital for PSI availability and reuse. Governments can adopt strategies like open data mandates and licensing reforms to boost transparency and promote public sector information dissemination (European Commission, 2019).

The maturity of OGD implementation should be assessed not merely by data availability but by its demonstrated contribution to sustainability outcomes. As this paper argues, the combination of institutional commitment, technical quality, and user engagement is key to unlocking the full potential of open data for achieving the SDGs (Benjira et al., 2025).

The Maturity of Open Government Data

The importance of OGD is growing alongside advancements in mass data processing (Big Data). The evolution of the Internet towards Web 3.0 has enabled the integration of data from various sources to generate new, valuable insights. The practice of linking data and the associated technologies is known as Linked Open Data (LOD). LOD is increasingly recognized as an effective approach aimed at enhancing information management and integration by simplifying access to a variety of open data sets. While the publication of open government data has increased globally, its semantic maturity stays low in many countries. According to recent research comparing 56 national OGD portals, the adoption of LOD principles is still limited, and only a few countries meet higher levels of semantic interoperability and linkage (Assem et al., 2024). These findings emphasize that opening data is not sufficient; enabling reuse also requires machine-readable formats, standard vocabularies, and public APIs.

As noted earlier, open data refers to data sets that anyone can share, use, process, and publish without restrictions under copyright and patent law, with the sole requirement of citing the data source or permitting further distribution of the processed content under the same conditions (Kozierski et al., 2013, pp. 8-9). Clearly defining open data and establishing a policy for its publication enhances interoperability among various sources and the potential for their combination. The ability to leverage open data depends on how it is published. It is vital that data is formatted and standardized in a machine-readable format to improve accessibility. Additionally, data should preferably be provided without the need for specific licenses, ensuring ease of use. Comprehensive metadata and contextual embedding are essential for enabling seamless integration of data from various sources.

The 5-star model, proposed by Berners-Lee (2006), is a commonly used measure of open data maturity. The subsequent steps of the 5-star model mean meeting certain requirements:

* Data accessible on the Internet under an open license, irrespective of format.

** Structured data availability preferred (e.g., Excel over scanned images of tables).

*** Non-proprietary open and structured format preferred (e.g., CSV over XLS).

**** Non-proprietary open and structured format with metadata, utilizing URIs to denote entities.

***** Non-proprietary open and structured format with metadata, incorporating data linkage to provide contextual information.

Open data is crucial for societal progress, fostering transparency, innovation, and economic growth. To maximize its impact, effective management requires robust monitoring and measurement. These practices assess usage, impact, and compliance with standards, helping organizations and policymakers improve accessibility, usability, and relevance.

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20

Accepting Editor: Meir Russ

In this effort, open data rankings play a crucial role, providing a structured framework for evaluating the performance and progress of open data initiatives across different domains. These rankings, often curated by reputable institutions and organizations, utilize multifaceted approaches to assess the quality, accessibility, and impact of open data repositories, platforms, and policies.

Several rankings compare Open Data by country, each with its own methodology and focus. To the authors' knowledge, the most current ranking is the Open Data Inventory (ODIN) (Open Data Watch 2024). This project, managed by Open Knowledge International, collects and analyzes data on OGD initiatives worldwide. It uses a scoring system to evaluate the completeness, timeliness, and accessibility of open data portals in 183 countries. As of February 2024, Singapore, Poland, Denmark, and Finland are the highest-ranked countries. Comprehensive evaluation criteria are central to the ranking process. These criteria cover multiple dimensions, including technical attributes like data format and interoperability, and broader considerations such as accessibility, user engagement, and the extent of data reuse. By aligning with established standards and best practices (Charalabidis et al., 2018), these criteria are used to benchmark open data initiatives and promote continuous improvement. It is important to note that each ranking has its own strengths and weaknesses, and no single ranking is perfect (Susha et al., 2015). When comparing countries, it is essential to consider the methodology used and the specific needs and interests of Open Data users. Assessing data openness is a complex task for several reasons. The first is the subjectivity of the assessment, which relies on factors such as context, purpose, and audience. For example, releasing raw data might be considered open to researchers, but requiring additional analytical tools or explanations could pose a barrier to casual users (Nikiforova & McBride, 2021).

Attempts to assess open data have been made for many years. The question remains: what should be assessed? The general classification of the assessed elements is presented, for instance, in the Open Data Barometer report (Web Foundation, 2016), which includes the assessment of:

- Readiness refers to a specific country's legal and organizational preparedness. It involves evaluating legal acts and various standards for publishing open data.
- Implementation refers to how the principles mentioned above are applied in practice. It encompasses an evaluation of the actual efforts made to publish open data and the technical aspects of data sharing.
- Impact, meaning the practical use of shared data and its benefits.

It can be concluded that the final element to be assessed should be the last one, i.e., impact. However, in practice, it is the most difficult to evaluate. Hence, many rankings focus on the first two elements of Readiness and Implementation. The latter seems to be the easiest to assess objectively; hence, numerous dimensions are defined, such as completeness, timeliness, format, usability, accuracy, interoperability, accessibility, community engagement, and licensing.

The analysis of open data recommendations results in the following key guidelines:

- Provide data and tools in a user-friendly way, using clear language, without requiring registration or contracts.
- Ensure high-quality, complete, and frequently updated data.
- Remove usage and licensing restrictions.
- Share data in machine-readable, open, and linkable formats.

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20

Accepting Editor: Meir Russ

- Include complete metadata descriptions.
- Publish data at the lowest possible aggregation level, with exceptions for privacy concerns.
- Keep data continuously updated and accessible in the same location, including via APIs.

Preparing Open Data rankings is a challenging task due to constantly changing landscapes and regulations. Openness often comes with trade-offs, such as privacy concerns, security risks, or resource limitations. The importance of specific openness aspects depends on the data and its intended use. For example, privacy concerns might be more critical for healthcare data than for weather data. Balancing these competing interests adds complexity to the assessment. Therefore, a nuanced and multifaceted approach is crucial when evaluating data openness. Researchers and organizations have developed various frameworks and methodologies to address this complexity. For instance, Donker and van Loenen (2017) proposed a holistic framework that assesses the success of open data ecosystems by integrating dimensions of data supply, governance, and user engagement. Similarly, Lnenicka et al. (2021) emphasized the importance of benchmarking open data initiatives through systematic analysis of indices and rankings to ensure comparability and contextual relevance. Earlier efforts, such as the draft framework developed by Caplan et al. (2014), aimed to establish common categories and indicators for assessing open data initiatives. Despite these advances, a universally accepted methodology for evaluating data openness has yet to emerge. Rankings serve as invaluable tools for strategic decision-making and resource allocation for stakeholders invested in the effective management of open data. By leveraging insights gained from these rankings, organizations can identify best practices, pinpoint areas for improvement, and formulate targeted interventions to optimize the impact and utility of their open data initiatives.

OGD-Based Public Transport Planner - Case Study

Methodological Approach

This paper adopts a descriptive case study approach to examine how OGD can be leveraged to develop value-added digital services in the context of public transportation. The analysis focuses on the JakDojade application, a widely used public transport planner in Poland. Data for this case study were collected through a combination of direct use by authors and observation of the application in its mobile version (as of early 2024), analysis of the official company website https://company.jakdojade.pl/o-firmie/, and secondary research. Furthermore, insights into user experience and business model development were informed by the authors' previous study, which analyzed user-generated reviews and platform evolution over time (Pawełoszek & Wieczorkowski, 2023). While this study does not include primary empirical data collection, it offers a theoretically informed and practice-oriented synthesis that highlights the opportunities and limitations of OGD-driven applications in smart mobility.

Functionalities and OGD Integration

Modern cities are complex ecosystems that implement innovative solutions designed to enhance resident comfort and sustainability. These advancements are possible thanks to the Internet of Things (IoT), which connects diverse physical systems such as vehicles, traffic lights, and buildings into a unified network (Shinde & Chavan, 2024). Smart mobility, an essential pillar of

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20
Accepting Editor: Meir Russ

the smart city concept, aims to optimize urban transportation. Its core objectives are to minimize empty mileage and traveled distances, ultimately easing traffic congestion by reducing the number of cars on the road (Ghorbani et al., 2023). Efficient vehicular traffic management becomes crucial in decreasing atmospheric pollution and energy consumption caused by automobiles (UNECE, 2024). Implementing intelligent transportation systems at the municipal level promises many benefits –environmental, economic, and social (Cepeliauskaite et al. 2021). In crowded urban agglomerations, public transport is a particularly important element. Many researchers discussing sustainability issues have already recognized the benefits of public transport (Ammenberg & Dahlgren, 2021; Lee & Kim, 2023).

Encouraging residents to use public transport requires ensuring convenience and accessibility (Tsafarakis et al. 2019). Travelers want to quickly find the best connections using the means of transport closest to their current location. The ideal solution to this problem is a mobile application that can locate the user and the nearest bus or tram stops, taking into account the route and travel time. The widespread adoption of mobile apps and the availability of high-speed internet pave the way for novel approaches to improving public transport services. JakDojade is the most popular mobile and web application in Poland, making planning travel by public transport easier. This tool lets users instantly search for bus, tram, and train connections. Although mainly associated with urban transport, it can also be used to plan intercity journeys. The application is constantly expanded with new functions. From December 2023, it was also possible to purchase tickets for a significant portion of railway routes through a partnership with PKP Intercity, the leading railway carrier in Poland. The JakDojade application is available in mobile and web versions for Android and iOS. As of 2024, it serves 50 Polish cities, including all the largest ones. The basic functionality consists of searching for optimal transport connections using current timetables and the user's up-to-date geolocation data. Possible transfers, walking times, and the actual locations of individual vehicles are taken into account. Passengers can also purchase tickets via the application. (https://company.jakdojade.pl/o-firmie/) (Wieczorkowski et al., 2021)

The RealTime functionality uses real-time data from the transport supervisor on each vehicle's current location. It improves the quality of connection search, taking into account vehicle location data. The passenger can also verify whether the specific bus or tram is likely to arrive at the stop on time. Moreover, dynamic route planning considers continuously updated actual vehicle speeds and travel times on individual road sections, not only schedule data. In large, dynamically changing urban street traffic, this option significantly enhances the planner's functionality, indirectly improving public transport quality and reducing environmental pollution. The RealTime function uses location data derived from GPS devices transmitted to the transport company and the public transport supervisor. However, it is necessary to continue making this information available via API interfaces.

Business Model and Sustainability Aspects

The overall business model of the JakDojade application producer is based on a service that widely uses typical big data and OGD solutions. Such characteristic methods include: the use of large volumes of data (geolocation information about the location of application users and public transport vehicles, timetable data, topographic maps with the location of stops and the route of communication lines); data processing in near real-time; processing of poorly structured streaming

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20
Accepting Editor: Meir Russ

data, in particular geolocation data; as well as combining data from many suppliers (public transport organizers, topographic map providers, cashless payment intermediaries), including OGD. As a result, we can discuss generating substantial added value that leads to the development of a new business model through the synergy of combining various data, including open data. This model has ensured the company's profitability over the past few years. The revenue source is advertising: the basic free version of the mobile application serves targeted ads, which users can opt out of in the paid premium version. For advertising purposes of other businesses, the company also sells location data obtained from users. An increasingly important part of the company's revenue comes from ticket sales via application. Therefore, it can be seen that profits are derived from multiple sources. The company uses acquired open external big data (such as vehicle schedules, locations, and maps) for its products. Simultaneously, it also employs its own generated data (collected from application users regarding their behavior, including geolocation) in internal business processes (such as passenger flow analysis) and for the products it offers (paid advertising delivery services). Additionally, the company generates income by selling its processed data (anonymized and aggregated user behavior data) to interested recipients, primarily in the advertising industry.

Given the implemented business model, the activity may only be profitable in larger towns with a sufficient market for advertising and ticket sales. However, local governments are increasingly willing to invest in financing to ensure adequate data access, which is a significant part of the fixed costs associated with integrating additional centers into the services provided. Local government data administrators are becoming more aware of the potential mutual benefits that can be achieved by sharing public sector information, aligning with the principles of sustainable development and smart cities. Residents can access additional, usually free services (in exchange for receiving advertisements) that enhance the convenience of using public transport or other public services, thereby positively influencing the perception of local authorities.

The study of the JakDojade application case illustrates that it is feasible to develop and successfully implement a business model focused on collecting and processing open data, particularly from the public sector, while ensuring sustainable profitability. The value of such data can be enhanced by integrating it with additional data or services. However, a challenge arises from the fixed costs associated with providing and downloading open government data, particularly for smaller cities. This is currently accomplished through bilateral agreements, which contrast with the idea of universal participation, where everyone should be able to use, reuse, and redistribute data. The requirement for non-discrimination is not fulfilled among the detailed specifications of the OGD, as data should be accessible to every entity without needing to sign contracts. The requirement for accessibility is also not met because the data is not published online. Standardizing access to open data through a public API could facilitate and lower the costs associated with obtaining such data. Therefore, in the situation described, we cannot discuss any level of maturity within the five-star model. It should be emphasized that the owners, in this case, local government bodies or entities acting on their behalf, are responsible for data sharing and for implementing effective OGD/PSI practices.

While JakDojade demonstrates a successful case of OGD-based innovation, some limitations persist. Access to real-time data is not standardized across all municipalities, and bilateral agreements are still required in many cases, limiting scalability. Furthermore, the application’s

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20

Accepting Editor: Meir Russ

business model, although sustainable in large urban areas, may be less viable in smaller cities without adequate public funding or advertising potential. These aspects underscore the need for greater inclusivity and open access to public transport data, ideally through standardized APIs and licensing models. Furthermore, although the application's business model is sustainable in larger cities, it may be difficult to replicate in smaller municipalities lacking sufficient demand or technical infrastructure. These disparities in digital readiness raise broader questions about data equity and inclusive access to OGD-based services. Ensuring open, standardized API access to transport data across all cities, regardless of size, is essential to democratizing innovation and fostering national-level sustainability.

OGD Maturity Assessment and Development Potential

To assess the maturity of the open government data used by the JakDojade application, the five-star model proposed by Berners-Lee (2006) was used as a benchmark. This framework — discussed earlier in the paper — provides a reference for evaluating the openness and interoperability of datasets. Figure 1 illustrates JakDojade's position within this model, showing that its functionality relies primarily on machine-readable, partially non-proprietary data formats, with limited integration of linked data.

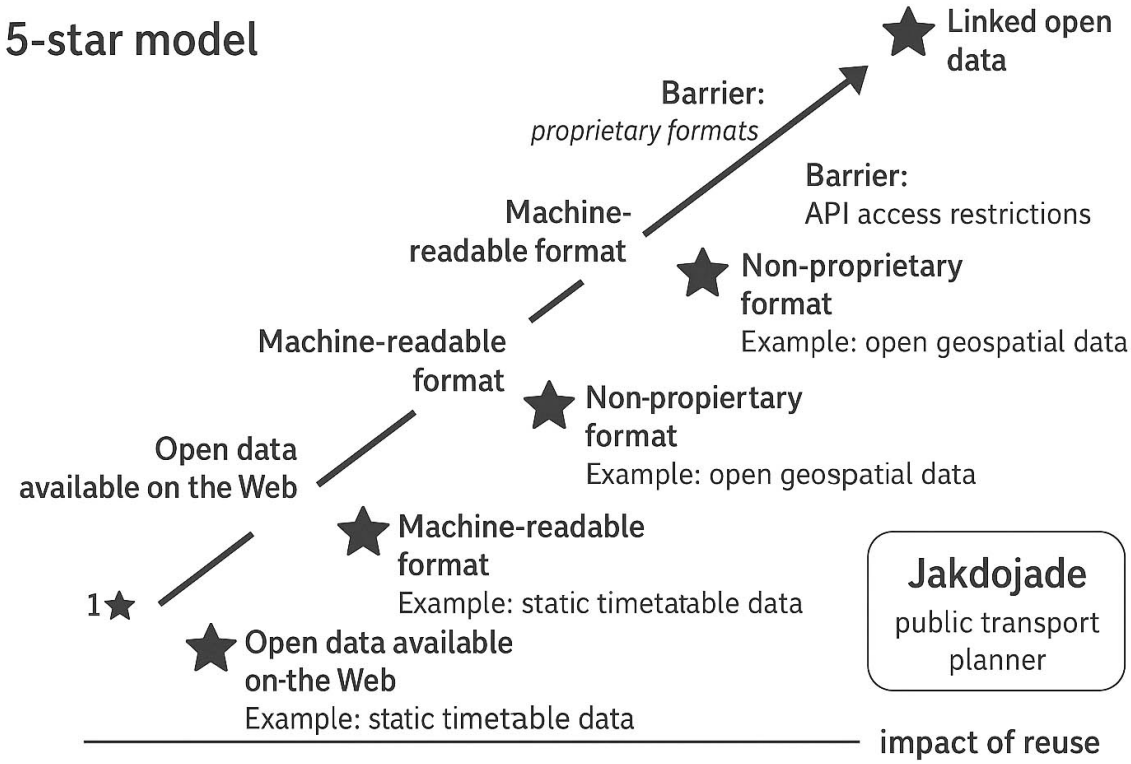

Figure 1. Placement of the JakDojade application within the 5-star open data maturity model. Source: Authors' elaboration based on Berners-Lee (2006)

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20
Accepting Editor: Meir Russ

In the case of JakDojade, the application relies on structured datasets provided by local governments and public transport operators, such as timetables and geolocation feeds. These are typically made available in reusable formats like CSV or JSON, often via custom APIs. Accordingly, the data infrastructure supporting JakDojade meets the criteria of two-star openness (★★), signifying availability in structured, machine-readable formats.

However, the application does not yet reach the third star (★★★), which requires open licensing and standardized metadata. Bilateral agreements often restrict access to real-time data and are not always accompanied by transparent terms of use. Furthermore, JakDojade does not currently use unique resource identifiers (URIs) for transport stops, lines, or schedules, which precludes reaching the fourth or fifth levels of the model. The absence of LOD integration and semantic referencing limits interoperability with other datasets. Figure 1 presents a visual summary of JakDojade's current position in the five-star model, along with key barriers to advancing toward higher levels of openness. The current level (★★) reflects reusable but partially restricted datasets. Arrows indicate pathways for improving transparency and interoperability. A detailed assessment of the criteria required to reach higher levels and the reasons why the JakDojade ecosystem currently falls short is provided in Table 3.

Table 3. Evaluation of the JakDojade Application Against the 5-Star OGD Model

Level	Requirements	JakDojade Status
★★★	Open format + license enabling unrestricted reuse	**Partially met** – data is machine-readable, but licensing is inconsistent or restricted by bilateral agreements
★★★★	Use of unique URIs for individual resources	❌ **Not met** – no standardized URIs for stops, routes, or cities
★★★★★	Linking data to other datasets (Linked Open Data)	❌ **Not met** – no integration with external datasets or semantic linking (e.g., Wikidata, DBpedia)

Despite these limitations, JakDojade illustrates how even mid-level OGD maturity can enable valuable public service innovation. Future development could include adopting open licensing schemes (e.g., Creative Commons), standardizing data using URI identifiers, and facilitating open, contract-free access to public transport data via APIs. These enhancements would elevate the dataset's maturity and unlock greater interoperability, scalability, and innovation potential, thereby contributing more effectively to smart city goals and broader PSI reuse.

Conclusions, Limitations, and Future Research

OGD draws upon long-standing concepts of transparency and knowledge sharing that date back to the 1940s. In the era of digital transformation and breakthrough technologies such as big data and artificial intelligence, these principles have gained renewed significance. The analysis presented in this paper confirms that the reuse of public sector information can significantly contribute to achieving the SDGs. The JakDojade case demonstrates how OGD-based applications can enhance

DOI: https://doi.org/10.36965/OJAKM.2025.13(2)1-20
Accepting Editor: Meir Russ

urban mobility, support environmental goals, and strengthen the digital economy through innovative data reuse.

From the perspective of economic and social sustainability, making public data with high utility available for reuse benefits both citizens and entrepreneurs. The creation of new digital services based on open data stimulates innovation and contributes to employment growth, particularly in the IT and data analytics sectors. The findings also show that the success of OGD-driven initiatives depends heavily on a country's technical infrastructure, including wireless network coverage, the prevalence of mobile devices, and the digital skills of its population.

From the standpoint of knowledge management, it is essential to share data in accordance with established open data practices. Standardized formats, machine-readable structures, and open APIs not only lower implementation and system maintenance costs but also improve interoperability across platforms. Ensuring open, non-discriminatory access to public data while respecting privacy and security requirements reduces market entry barriers for new companies and encourages the development of innovative products and services aligned with sustainable development goals.

These findings illustrate both the business viability and societal value of OGD-based services, as well as the importance of regulatory and infrastructural support for data openness. The JakDojade case may serve as a model of public–private collaboration, where digital innovation aligns with public interest and contributes to sustainable urban development. However, this study has certain limitations. The analysis focused on a particular single case – JakDojade – operating in a technologically advanced environment with high levels of digital infrastructure and user readiness. Consequently, the results may not fully reflect conditions in smaller municipalities or regions with less advanced digital ecosystems.

Future research could investigate user adoption of OGD-based applications in smaller cities and rural areas, where digital infrastructure and service demand are more constrained. Comparative studies on policy frameworks and API accessibility across municipalities may also identify best practices for promoting innovation through open data. Further longitudinal research could assess the long-term social and economic impact of OGD-based solutions within smart city ecosystems and their contribution to digital sustainability.

References

Adams, C., Allen, J., & Flack, F. (2022). *Sharing linked data for health research: Towards better decision making.* Cambridge University Press. https://doi.org/10.1017/9781108675789

Ammenberg, J., & Dahlgren, S. (2021). Sustainability assessment of public transport, part I—A multi-criteria assessment method to compare different bus technologies. *Sustainability*, *13*, 825. https://doi.org/10.3390/su13020825

Assem, M., Khadraoui, D., Karkouch, A., & Benhadda, H. (2024). The linked open data maturity of open government data portals: A worldwide comparison. *Future Internet*, 16(3), 99. https://doi.org/10.3390/fi16030099

Bauhr, M., Czibik, Á., & Fazekas, M. (2020). Lights on the shadows of public procurement: Transparency as an antidote to corruption. *Governance*, 33(3), 495–523. https://doi.org/10.1111/gove.12432

Begany, G. M., Martin, E. G., & Yuan, X. (2021). Open government data portals: Predictors of site engagement among early users of Health Data NY. *Government Information Quarterly, 38*(4), 101614. https://doi.org/10.1016/j.giq.2021.101614

Benjira, W., Atigui, F., Bucher, B., Grim-Yefsah, M., & Travers, N. (2025). Automated mapping between SDG indicators and open data: An LLM-augmented knowledge graph approach. *Data & Knowledge Engineering, 156*, 102405. https://doi.org/10.1016/j.datak.2024.102405

Berners-Lee, T. (2006). Linked data: Design issues. http://www.w3.org/DesignIssues/LinkedData.html

Bhandekar, R. Y., Gobade, S., Dhake, S., & Kanhekar, R. (2024). WSN-based data acquisition system for collecting environmental pollution factors for green city. *International Journal of Advanced Research in Science, Communication and Technology, 3*(2). https://doi.org/10.48175/ijarsct-18307

Brzustewicz, P., Escher, I., Hermes, J., & Ulkuniemi, P. (2021). Value creation in company–NGO collaboration in corporate volunteering. *Journal of Business & Industrial Marketing, 36*(8), 1504–1519. https://doi.org/10.1108/JBIM-01-2020-0057

Buedeler, W. (1957). *The international geophysical year*.

Caplan, R., Davies, T., Wadud, A., Verhulst, S., & Alonso, J. M. (2014). *Towards common methods for assessing open data: Workshop report & draft framework*. The Governance Lab, Open Data Research Network.

Costa Climent, R., Haftor, D. M., & Staniewski, M. W. (2024). AI-enabled business models for competitive advantage. *Journal of Innovation & Knowledge, 9*(1), 100532. https://doi.org/10.1016/j.jik.2024.100532

Cepeliauskaite, G., Keppner, B., Simkute, Z., Stasiskiene, Z., Leuser, L., Kalnina, I., Kotovica, N. Andiņš, J. & Muiste, M. (2021). Smart-mobility services for climate mitigation in urban areas: Case studies of Baltic countries and Germany. *Sustainability*, 13, 4127.

Charalabidis, Y., Zuiderwijk, A., Alexopoulos, C., Janssen, M., Lampoltshammer, T., & Ferro, E. (2018). Open data evaluation models: Theory and practice. In T. Janssen, Y. Charalabidis, & A. Zuiderwijk (Eds.), *The world of open data* (Public Administration and Information Technology, Vol. 28, pp. 85–107). Springer. https://doi.org/10.1007/978-3-319-90850-2_8

Curristine, T., & Abbott, B. (ed.) (2005). *Modernising government: The way forward*, OECD Publishing.

Davies, T., Walker, S. B., Rubinstein, M., & Perini, F. (Eds.). (2019). *The state of open data: Histories and horizons.* Cape Town & Ottawa: African Minds & International

Development Research Centre. https://idrc-crdi.ca/sites/default/files/openebooks/open-data/9781552506127.html

Donker, F. W., & van Loenen, B. (2017). How to assess the success of the open data ecosystem? *International Journal of Digital Earth, 10*(3), 284–306. https://doi.org/10.1080/17538947.2016.1224938

European Environment Agency (EEA). (2025). *Indicators: Climate and environment data for Europe.* European Environment Agency. https://www.eea.europa.eu/en/analysis/indicators

European Commission. (2019). *Directive (EU) 2019/1024 of the European Parliament and of the Council on open data and the re-use of public sector information. Official Journal of the European Union, L172*, 56–83.

Ghorbani, E., Fluechter, T., Calvet, L., Ammouriova, M., Panadero, J., & Juan, A. A. (2023). *Optimizing energy consumption in smart cities' mobility: Electric vehicles, algorithms, and collaborative economy. Energies, 16*(3), 1268. https://doi.org/10.3390/en16031268

Glavee-Geo, R., Al Ahmed, S. W. U., Tippett, A. W., Grimstad, S. M. F., & Pasquine, M. (2023). The role of non-profit organisations (NGOs) in value creation: Lessons from the recycling of fishing gear in Norway. In S. M. F. Grimstad, L. M. Ottosen, & N. A. James (Eds.), *Marine plastics: Innovative solutions to tackling waste* (pp. 143–160). Cham: Springer. https://doi.org/10.1007/978-3-031-31058-4_9

Intergovernmental Panel on Climate Change (IPCC). (2021). *Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (V. Masson-Delmotte, A. Pirani, S. L. Connors, C. Péan, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou, Eds.). Cambridge University Press. https://doi.org/10.1017/9781009157896

JakDojade (2025). https://company.jakdojade.pl/o-firmie/

Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, adoption barriers and myths of open data and open government. *Information Systems Management*, 29(4), 258–268. https://doi.org/10.1080/10580530.2012.716740

Janssen, M., & Kuk, G. (2016). The challenges and limits of big data algorithms in technocratic governance. *Government Information Quarterly, 33*(3), 371–377. https://doi.org/10.1016/j.giq.2016.08.011

Jetzek, T., Avital, M., & Bjorn-Andersen, N. (2014). Data-driven innovation through open government data. *Journal of Theoretical and Applied Electronic Commerce Research, 9*(2), 100–120. https://doi.org/10.4067/S0718-18762014000200008

Japan Meteorological Agency (JMA). (2025). *Japan meteorological agency – Meteorological services of Japan.* Japan Meteorological Agency. https://www.jma.go.jp/jma/indexe.html

Kozierski P., Kabaciński R., Lis M., & Kaczmarek P. (2013). *Analiza zjawiska z punktu widzenia polskiego naukowca [Analysis of the Phenomenon from the Polish Scientist's Point of View]*, Impuls.

Kumari, S., & Dayal, R. (2025). Leveraging data analytics to bridge educational inequities globally. *Proceedings in Interdisciplinary Insights and Innovations, 3*, 497. https://doi.org/10.56294/piii2025497

Lassinantti, J. (2019). Reuse of public sector open data – characterising the phenomena. *International Journal of Enterprise Information Systems*, 13, 1-29.

Lassinantti, J., Ståhlbröst, A., & Runardotter, M. (2019). Relevant social groups for open data use and engagement. *Government Information Quarterly, 36*(1), 98–111. https://doi.org/10.1016/j.giq.2018.11.001

Lee, J., & Kim, J. (2023). Social equity analysis of public transit accessibility to healthcare might be erroneous when travel time uncertainty impacts are overlooked. *Travel Behaviour and Society*, 32, 100588. https://doi.org/10.1016/j.tbs.2023.100588

Lnenicka, M., Luterek, M., & Nikiforova, A. (2021). Benchmarking open data efforts through indices and rankings: Assessing development and contexts of use. *Telematics and Informatics, 62*, 101622. https://doi.org/10.1016/j.tele.2021.101622

Mayer-Schonberger, V., & Cukier, K. (2013). *Big data: A revolution that will transform how we live, work, and think*, Houghton Mifflin Harcourt.

National Oceanic and Atmospheric Administration (NOAA). (2023). *Global climate report – annual 2023.* National Centers for Environmental Information. https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202313

Navoica (2025). *NAVOICA – the Polish MOOC of education*. https://opi.org.pl/en/navoica-the-polish-mooc-of-education/

Niankara, I. (2022). Sustainability through open data sharing and reuse in the digital economy. *Proceedings of the 2022 International Arab Conference on Information Technology (ACIT)* (pp. 1–11). IEEE. https://doi.org/10.1109/ACIT57182.2022.9994191

Nikiforova, A., & McBride, K. (2021). *Open government data portal usability: A user-centred usability analysis of 41 open government data portals. Telematics and Informatics, 63*, 101660. https://doi.org/10.1016/j.tele.2020.101539

Open Data Watch. (2024). *Open Data Inventory (ODIN) 2024/25.* Open Data Watch. https://odin.opendatawatch.com/

Open Knowledge Foundation (2025), *What is open?* https://okfn.org/en/library/what-is-open/

Open Knowledge Foundation. (2024). *OpenSpending*. https://openspending.org/

Pawełoszek, I., & Wieczorkowski, J. (2023). Trip planning mobile application: A perspective case study of user experience. *Engineering Management in Production and Services*, 15(2), 55-71. https://doi.org/10.2478/emj-2023-0012

Pizzamiglio, A. (2024). *Exploring business models for public open data resources: Insights and recommendations from the data.europa.eu campaign*. Publications Office of the European Union. https://data.europa.eu/sites/default/files/report/Exploring%20business%20models%20for%20public%20open%20data%20resources.pdf

Public Domain Manifesto (2010). https://publicdomainmanifesto.org/

Shinde, S., & Chavan, T. (2024). Leveraging the Internet of Things (IoT) for smart city innovation: Exploring applications, overcoming challenges, and charting future pathways. *International Journal of Scientific Research in Modern Science and Technology, 3*(9). https://doi.org/10.59828/ijsrmst.v3i9.250

Sieber, R. E., & Johnson, P. A. (2015). Civic open data at a crossroads: Dominant models and current challenges. *Government Information Quarterly*, 32(3), 308–315. https://doi.org/10.1016/j.giq.2015.05.003

Smyrnova-Trybulska, E., Sekret, I., & Morze, N. (2021). Preliminary analysis of the development and implementation of the MOOC project: A case study. *E-learning*, 13, 137–150. https://doi.org/10.34916/el.2021.13.12

Stephan, P.E. (2004). Robert K. Merton's perspective on priority and the provision of the public good knowledge. *Scientometrics,* 60, 81–87. https://doi.org/10.1023/B:SCIE.0000027311.17226.70

Stewart, K. (2018). *Is your open data 5-star?*. ESRI. https://resources.esri.ca/arcgis-online/is-your-open-data-5-star

Susha, I., Zuiderwijk, A., Janssen, M., & Grönlund, Å. (2015). Benchmarks for evaluating the progress of open data adoption: Usage, limitations, and lessons learned. *Social Science Computer Review, 33*(5), 613–630. https://doi.org/10.1177/0894439314560852

The Data Foundation. (2022). *Data literacy for the public sector: Lessons from early pioneers in the U.S.* Evidence Act Hub. https://datafoundation.org/news/evidence-act-hub/22/22-Data-Literacy-for-the-Public-Sector-Lessons-from-Early-Pioneers-in-the-US

Tsafarakis, S., Gkorezis, P., Nalmpantis, D., Genitsaris, E., Andronikidis, A., & Altsitsiadis, E. (2019). Investigating the preferences of individuals on public transport innovations using the Maximum Difference Scaling method. *European Transport Research Review*, 11(1), 3. https://doi.org/10.1186/s12544-018-0340-6

United Nations Economic Commission for Europe (UNECE). (2025). *Transport trends and economics.* United Nations Economic Commission for Europe. https://unece.org/transport/trends-and-economics

UNESCO. (2019). *Recommendation on Open Educational Resources (OER).* Paris: UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000370936

United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development.* United Nations. https://sdgs.un.org/2030agenda

United Nations Human Settlements Programme (UN-Habitat). (2020). *World cities report 2020: The value of sustainable urbanization.* United Nations Human Settlements Programme. https://unhabitat.org/world-cities-report-2020-the-value-of-sustainable-urbanization

United States Environmental Protection Agency (EPA). (2025). *Greenhouse gas emissions data.* Environmental Protection Agency. https://www.epa.gov/ghgemissions

Veljković, N., Bogdanović-Dinić, S., & Stoimenov, L. (2014). Benchmarking open government: An open data perspective. *Government Information Quarterly, 31*(2), 278–290. https://doi.org/10.1016/j.giq.2013.10.011

Web Foundation (2016). *Open data barometer. ODB Global Report. Third Edition*, Web Foundation, http://opendatabarometer.org/doc/3rdEdition/ODB-3rdEdition-GlobalReport.pdf

Wehner, J., & de Renzio, P. (2013). Citizens, legislators, and executive disclosure: The political determinants of fiscal transparency. *World Development*, 41, 96–108. https://doi.org/10.1016/j.worlddev.2012.06.005

Wieczorkowski, J., Chomiak-Orsa, I., & Pawełoszek, I. (2021), *Big data w zarządzaniu [Big data in management]*, Polskie Wydawnictwo Ekonomiczne.

Zuiderwijk, A., Shinde, R., & Janssen, M. (2019). Investigating the attainment of open government data objectives: Is there a mismatch between objectives and results? *International Review of Administrative Sciences, 85*(4), 645–672. https://doi.org/10.1177/0020852317739115

Authors Biographies

Jędrzej Wieczorkowski, Ph.D., is an assistant professor at the SGH Warsaw School of Economics, Poland, in the Institute of Information Systems and Digital Economy. He is also an analyst and consultant on IT projects and an expert in evaluating such projects. His research interests include IT applications in management, management of IT projects, economic and social applications, and consequences of the big data and artificial intelligence concepts, and the use of public sector information / open government data.

Ilona Pawełoszek, Ph.D., is an assistant professor at the Faculty of Management, Czestochowa University of Technology, Poland. Her research interests focus on the application of artificial intelligence, digital technologies, and spatial analysis in management. She has published on topics such as Industry 4.0, knowledge representation, and communication in distributed organizations. She also teaches courses on e-commerce, operations management, and geographical information systems.