Towards the Development of Interoperable Open Data Ecosystems: Harnessing the Technical, Semantic, Legal, and Organizational (TSLO) Interoperability Framework

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ABSTRACT

The development of ecosystems around open government data in order to generate social and economic value from them requires on one hand the existence of a critical mass of them and on the other hand some level of homogeneity and interoperability among the numerous portals and websites providing them which enables their combined exploitation. This paper presents the Technical, Semantic, Legal, and Organizational (TSLO) Interoperability Framework, a conceptual tool designed to provide a structured evaluation of the interoperability capabilities of open government data infrastructures. It incorporates the technical, semantic, legal, and organizational aspects of open government data provision, which are crucial for developing interoperability between open data portals and websites, which enables the generation of high levels of social and economic value from them, so it can pave the way for creating open data ecosystems for this purpose. We are then applying this TSLO framework to examine from this perspective the open data infrastructures of the Greek local government administration institutions of all three layers of it (decentralized, regional, and municipal). In particular, we examine the open government data portals and websites of the local Greek governments and provide a detailed analysis of them concerning the fore aspects of the framework. This first application of TSLO reveals not only the low participation of Greek local government institutions in the open data movement, and especially of the municipalities, where only 8 out of 332 municipalities provide open data on their portals or websites but also the inconsistent implementation of this, especially with respect to the use of semantic technologies as well as the legal frameworks under which the open data provided. Finally, we propose the automation of the TSLO framework to facilitate the evaluation and standardization of open local government data infrastructure and expand the study to identify and address barriers to open data provision.

1 INTRODUCTION

The importance of open data in contemporary governmental organizations is increasingly recognized; there is a plethora of academic research that reveals its importance in the cultivation of civic trust, the promotion of administrative transparency, and the boost in economic growth [17, 18]. The embrace of open data provision took its contemporary form initially with the launch of the Open Data Foundation in 2004, and at a government level, with the United States government pioneering it with the release of open government data through their data.gov portal. This approach to a more open and transparent way of data management was gradually adopted by other governments globally.

The impact of open data on the local levels of public administration can have an even more profound effect than on central layers of government since it is closer to the citizens. Local government can directly address citizens' needs, and cultivate a more profound sense of community [15], and the provision of open data can not only increase transparency and accountability for the local officials concerning the achievement of the above objectives but also create opportunities for economic development at local levels, which is much needed, especially in rural and disconnected areas. However, to achieve these objectives it is necessary: a) large numbers of local government organizations to provide large quantities of open government data, and b) to achieve a high level of homogeneity and interoperability among the open government infrastructure of the numerous local government organizations, which enables the combined exploitation of them; this can significantly increase the

social and economic value that can be generated from them (as the value that can be generated from the use of open data of only one local government organizations is limited), and can contribute to the development of larger and wider ecosystems around these open data for generating social and economic value from them. These interoperable local government open data portals and websites are a vital component in creating an open data ecosystem that can multiply the benefits each institution can provide on its own. Businesses can efficiently utilize and combine data from different institutions and provide added value services, and also the local governments themselves can compare their performance in various aspects of their operation with the performances of other local governments, possibly get inspired from them and offer better services to their citizens; furthermore, active citizens and journalists can comparatively evaluate the local governments boosting accountability and transparency overall.

Several important factors, such as technical, semantic, organizational, and legal ones, significantly impact the functioning and effectiveness of the interoperability within the context of the open data ecosystems. Semantic interoperability enables a common meaning and understanding of open data by outlining the relationships and definitions of data objects, which is crucial for drawing valid conclusions and generate high levels of value from multiple open data sources [12, 16]. To facilitate effective collaboration and sustainable development, highly important are organizational dimensions that include particular responsibilities and governance mechanisms within the ecosystem concerning the opening and use of data [9]. Data licensing, privacy, and regulatory frameworks are all part of the legal standards that control data transmission and usage, which also affect this collaboration and value generation; the constraints and ethical considerations for data management are laid forth in these requirements. On the other hand, data formats, and standards are defined in technical interoperability dimensions. Within the ecosystem, they ensure that various systems may cooperate and exchange data without difficulties. These norms are significant because they may enhance transparency, promote collaboration, and encourage innovation all at once. To build a robust open data ecosystem, it is essential to meet the distinct needs of each standard. This approach ensures that the data is technically feasible to combine and logically consistent, and that its use is also ethically and legally sound [7, 8, 19]. The open data ecosystem cannot be built without these prerequisites, which allow for the ethical, legal, and effective usage of data for social and economic value generation.

This paper aims to develop a TSLO (Technical, Semantic, Legal, and Organizational) framework for analyzing the interoperability among open data portals and websites of different local government organizations. This framework serves as a conceptual tool for evaluating from the interoperability perspective the open data infrastructures in these four dimensions that play a pivotal role in developing interoperability capacities.

Based on this TSLO framework we analyze the open data infrastructure of local government institutions of Greece in order to assess their interoperability capacity. In Greece, the initiative to open government data to the society and the economy is a journey that started more than a decade ago; it has also been supported not only by the government but also by non-governmental organizations

like Open Knowledge Greece, which started its activities in 2012 and is part of the Open Knowledge International since 2013. Furthermore, some academic studies have been conducted concerning the investigation and evaluation of the open data status in Greece, although their focus was either on the digital transformation of the local governments [3] or on the general adoption of open data provision in all the administration levels of the Greek government [1, 2]. Thus, we observe a notable research gap in the examination of the state that open data provision by local government in Greece at all its layers (municipal, regional, and decentralized administrations).

Therefore, our research objectives are:

- RQ1: Develop an integrated framework for analyzing open data infrastructures with respect to their interoperability concerning the abovementioned four dimensions.
- RQ2: Examine to what extent are open data available through local government administration infrastructures in Greece, and analyze their interoperability capacities using the above framework.

In Greece, the initiative to open government data to the society and the economy is a journey that started more than a decade ago; it has also been supported not only by the government but also by non-governmental organizations like Open Knowledge Greece, which started its activities in 2012 and is part of the Open Knowledge International since 2013. Furthermore, some academic studies have been conducted concerning the investigation and evaluation of the open data status in Greece, although their focus was either on the digital transformation of the local governments [3] or on the general adoption of open data provision in all the administration levels of the Greek government [1, 2]. Thus, we observe a notable research gap in the examination of the state that open data provision by local government in Greece at all its layers (municipal, regional, and decentralized administrations). Based on the availability of local government open data and the technical capabilities of them we determine research gaps and future research directions that other researchers could utilize to improve the impact that local government data have in Greece as well as on a global scale.

This paper consists of six sections. In section 2 related work is described. In section 3 we describe the TSLO framework, while section 4 presents the method and data of its application in the context of Greek local government. The results of this application are presented in section 5. We conclude with sections 6 and 7, which include a discussion and the conclusions of our research respectively.

2 RELATED WORK

As a first step in our research, we conducted a literature review to identify studies that examine the opening of data by local governments. In this section, we present the most important of the academic publications that we pinpointed to be related to our research topic. The most relevant research we identified was a paper that evaluated the capabilities of local governments' portals in Australia concerning the provision of open data and the impact of their release at a local level [4]. Several similar studies were identified from various countries, including Taiwan, South Korea, and South Africa, with different focus on each case. In particular, [20] examines open data provided by local governments in Taiwan, with the

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main emphasis on the evaluation of the quality of open data using the five-star ranking system. In [11] the focus was placed on the identification of the factors that lead to increased adoption of open data from local communities in South Korea, and the benefits they can reap from these initiatives [11]. In the research described in [10] the primary purpose was the examination of the use of open data from municipalities in order to promote a culture of transparency and accountability.

Additionally, we identified two papers examining the digital transformation and the websites of local government organizations in Greece, with only a minor emphasis on open data [3, 18]. Furthermore, there are some studies are dealing with factors and motivations that influenced the growth of open data in Greece, such as citizen empowerment and elimination of corruption [13], and lean management of public services [3]. On the other hand, this does not imply that the potential advantages of open data are not presented with any obstacles. These challenges include the restricted usage of data, the possibility of privacy concerns, and the need for improved technological skills [16]. In the course of the nation's efforts to address these difficulties, build cooperation between the state and interested parties, and make use of open data to fuel innovation and economic progress, there are substantial opportunities for improvement [3]. Launches such as Data.gov.gr, which is Greece's National Open Data Portal, are evidence of the country's unwavering commitment to developing the open data realm [5]. To fully appreciate the social and economic advantages that open data can offer, it is necessary to address concerns such as the accessibility of data, the quality of data, and the regulatory frameworks that govern open data [14].

3 THE TSLO FRAMEWORK

Initially, we developed a framework for evaluating the open data infrastructures of local government administration institutions of all levels (decentralized, municipal, and regional) from the interoperability perspective. The framework examines the interoperability of open government data portals and websites from the technical, semantic, legal and organizational (TSLO) perspectives, which are crucial for developing interoperability between open data infrastructure and can pave the way for creating an open data ecosystem. The TSLO framework is aligned with the European interoperability framework (EIF) [6]. The EIF defines the main layers of interoperability, such as organisational, legal, semantic, and technical. However, these interoperability dimensions are not elaborated and explored in depth for open data interoperability in the EIF. In this research, these dimensions have been explored in depth for open data portals and websites of local government. For instance, what metrics have to be included in the technical interoperability layer? What metrics make up the semantic interoperability layer?

The definitions and understanding of each of the dimensions in the TSLO framework are based on the EIF [6]:

Technical dimensions cover "the applications and infrastructures linking systems and services. Aspects of technical interoperability include interface specifications, interconnection services, data integration services, data presentation and exchange, and secure communication protocols."

Semantic dimensions ensure "that the precise format and meaning of exchanged data and information is preserved and understood throughout exchanges between parties; in other words, 'what is sent is what is understood'."

Legal dimensions are "about ensuring that organisations operating under different legal frameworks, policies, and strategies are able to work together. This might require that legislation does not block the establishment of European public services within and between Member States and that there are clear agreements about how to deal with differences in legislation across borders, including the option of putting in place new legislation."

Organisational dimensions refer "to the way in which public administrations align their business processes, responsibilities, and expectations to achieve commonly agreed-upon and mutually beneficial goals."

Based on the above conceptualizations for each dimension have been defined a number of metrics, which are presented in Figure 1. These metrics are logically and conceptually connected with each dimension. For example, data access method, API availability, and underlying open data CMS are related to technical dimensions. In this way, all the corresponding metrics for each dimension have been placed. This structured evaluation platform is crucial for developing interoperability among OGD infrastructures and paving the way for the creation of open data ecosystems.

4 TSLO APPLICATION IN THE CONTEXT OF GREEK LOCAL GOVERNMENT

The main objective of this application of TSLO framework revolved around the evaluation of open government data portals and websites of Greek local government across the various administrative layers of it with respect to the evaluation dimensions and the metrics of TSLO; such an evaluation reveals the potential for combined utilization of this open data portals and websites (use and combine open data from many different open data portals and websites) for the generation of high levels of social and economic value, which constitutes the main motivation and pre-condition for the development of ecosystems for this purpose. Initially, an assessment of the availability of these portals and websites was conducted. Additionally, desk-based research was undertaken to gather data on the technical, semantic, legal, and organizational metrics concerning the existing Greek open government data infrastructures. Furthermore, the collection of data pertaining to these metrics was imperative to showcase the functionality of our developed framework and its effectiveness. Through the utilization of Greek open government data as a principal use case, this research endeavors to illuminate the operational dynamics and effectiveness of the aforementioned multi-metrics framework. The methodology we followed for this application of the TSLO framework is shown in Figure 2.

There are three layers of local government in Greece: decentralized administration, regional administration, and municipalities: in particular, there are 7 decentralized administrations, 13 regional administrations, and 332 municipalities. We conducted a combination of searches, initially on all local government websites using their search functionalities and menus. Subsequently, we used queries in web search engines, constructed to identify mentions of open data

Figure 1: TSLO dimensions for the interoperability evaluation of local government open data portals

on all the local government websites. We retained only those local government entities providing open data through their dedicated infrastructure. Specifically, we excluded those entities that provide data through the national open data portal. Our methodology evaluates the local government organizations that have such portals or websites using the TSLO framework with respect to its technical, semantic, legal, and organizational metrics. From the decentralized administration level, we identified only one organization that has a data portal, from the regional administrations we classified four institutions two of them have data portals (Attica and Central Greece) and two (Western Macedonia and the Ionian Islands) host open data files in their website. Finally, at the municipality level, we identified that five have data portals (Heraklion, Thessaloniki, Malevizi, Trikkaia, Chalandion) and 3 host open data on their websites (Larissa, Patra and Rhodes).

This application of the TSLO framework aims to identify weaknesses — technological, semantic, legal, or organizational ones — in the open data infrastructure of the Greek local government that might hinder the availability and utilization of open government data for the generation of social and economic value, and therefore reveal relevant improvement opportunities. Each of the four dimensions of the TSLO framework includes a number of metrics that aim to assess important aspects of this dimension for the open data infrastructure; these metrics include really important aspects, among others, the availability of APIs, access to data, integration

with other portals, the quality of data, data formats, the licensing for data, data usage rights, data governance structure, and data workflow.

5 RESULTS OF TSLO APPLICATION

A first conclusion from this application of the TSLO framework was that only a small minority of municipalities (8/332) and decentralized administration (1/7) provide open government data; furthermore, nearly a quarter of the regional administrations (4/13) have proceeded to the provision of open government data. Some more local governments provide open data through the national open data portal. This indicates a low participation of municipalities as well as regional and decentralized administration in the open data movement with their own infrastructure, as well as a low awareness and understanding of the social, political and economic benefits that the opening of local government data can offer; furthermore, this does not allow the generation of high levels of social and economic value through by combining open data from large numbers of municipalities and decentralized administration, so there are not strong motivations for the development of ecosystems for this purpose around open data. However, in regional level of government, there is a higher participation in the open data movement, which reveals some higher awareness and understanding of these potential benefits that the opening of their data can offer; this allows to a higher extent a combination of the open data they
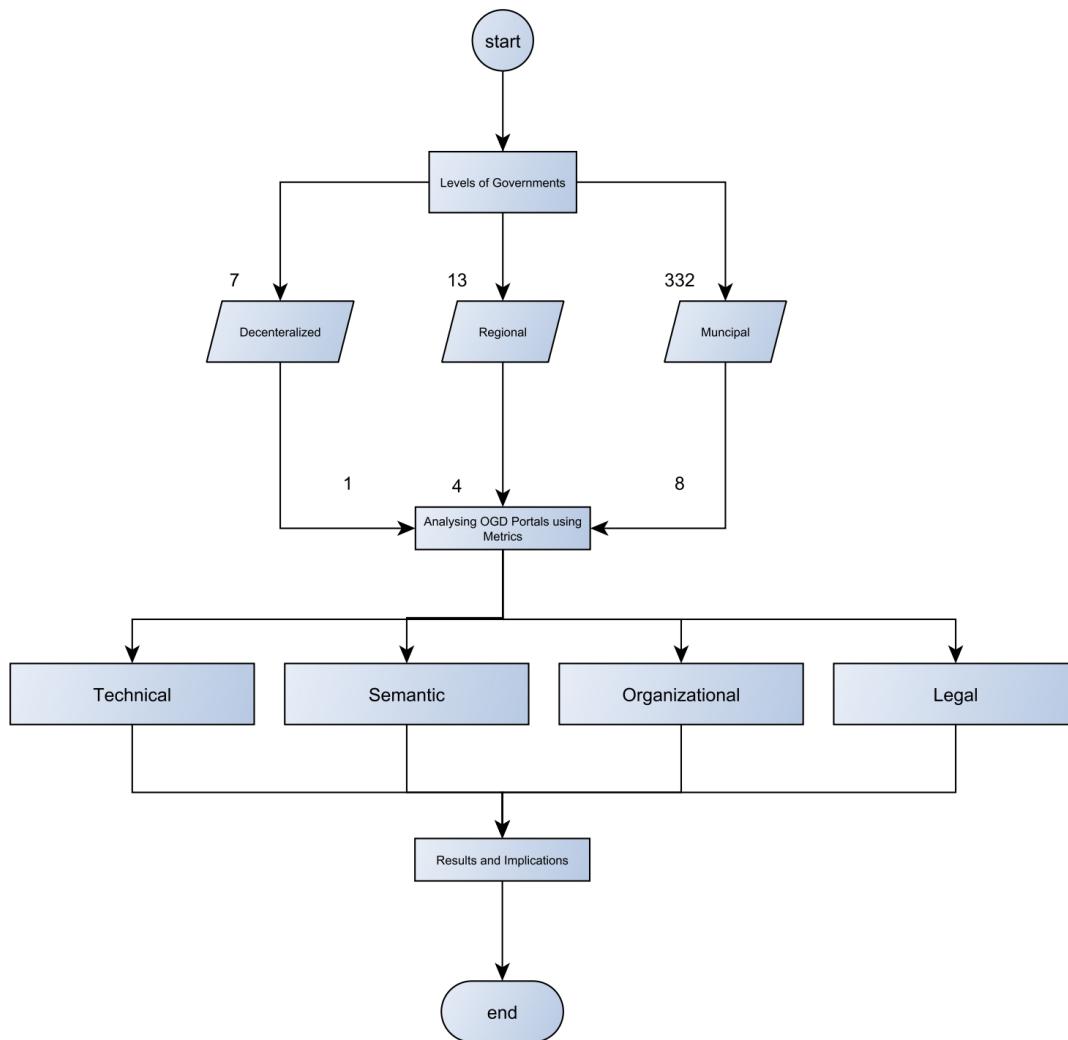
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Figure 2: Methodology for the application of the TSLO framework for Local Greek government

provide, and therefore a higher level of social and economic value generation, so it provides some motivation for the development of ecosystems for this purpose around open data.

5.1 Technical dimension

Initially, we evaluated the existing open data infrastructure of the local government (decentralized, regional, and municipal) administrations with respect to the 12 main aspects/metrics of the technical dimension mentioned in section 3. These aspects/metrics are important technical requirements for an open data portal. For instance, a portal should mention how many datasets are available, the metadata of the datasets (publishers, dates, descriptions, etc.), and the data formats in which data is available (The portal mentions overall what the highest level of data formats supported? e.g. many of the portals supports up to 2 stars?), data access methods (e.g., direct download and API based access), the use of underlying CMSs (the

framework just analyzes if any of the CMS is utilized in the portal in Boolean - Yes/No e.g., portals use different CMSs such as CKAN, DKAN, SOCRATA, and sometimes custom-developed CMS); data filtering and searching functionalities; integrated data visualization tools; data update frequency (monthly, quarterly, semi-annually, annually); multi-lingual support (built-in); and the performance and scalability of the portal. The results of this evaluation are shown in Tables 1, 2 and 3.

In Table 1 we can see the results for the only existing open data portal of decentralized administration: the one of Crete; we can see that it meets 11 out of the 12 metrics, with the only deficiency being the lack of multi-languality. In Table 2 we can see the results for the four regions that have open data infrastructure. Most of them meet a significant part of the technical metrics (one meets 8 criteria, one meets 9 criteria and one meets 10 criteria), and only one meets only less than half of the criteria (5). The main deficiencies

Table 1: Technical dimension metrics for the decentralized administration open data infrastructure

Technical metrics	Crete
Performance and Scalability	✓
Integration with External Systems	✓
Multi-language Support	×
Data Update Frequency	✓
Data Visualization Tools (Limited)	✓
Data Filtering and Search	✓
Data Metadata (Limited)	✓
Underlying OD CMS (CKAN, DKAN, Socrata, Custom etc.)	✓
Data Access Methods (Direct Download)	✓
API Availability	✓
Data Formats Supported (Up to 2 Star)	✓
Thematic Categorization	✓

Table 2: Technical dimension metrics for the regional administrations' open data infrastructure

Technical metrics	Attica	Western Macedonia	Ionian Islands	Central Greece
Performance and Scalability	✓	×	✓	✓
Integration with External Systems	×	×	✓	×
Multi-language Support	×	×	×	✓
Data Update Frequency	×	✓	×	✓
Data Visualization Tools (Limited)	✓	×	✓	×
Data Filtering and Search	✓	×	✓	✓
Data Metadata (Limited)	✓	✓	✓	✓
Underlying OD CMS (CKAN, DKAN, Socrata, Custom etc.)	✓	✓	✓	✓
Data Access Methods (Direct Download)	✓	✓	✓	✓
API Availability	×	×	×	✓
Data Formats Supported (Up to 2 Star)	✓	×	✓	✓
Thematic Categorization	✓	✓	✓	✓

in the regional administrations' data infrastructure concern the lack of multi-linguality, API availability, and data update frequency. Finally, in Table 3 we can see the results for the eight municipalities that have open data infrastructure. Three of them meet a significant part of the technical metrics (9 or more), while the remaining five meet less metrics (however more than half of them). The main deficiencies in the municipalities' open data infrastructure concern the lack of integration with external systems, API availability and multi-linguality.

5.2 Semantic dimension

Tables 4, 5 and 6 show the results of evaluation with respect to the 7 semantic dimension metrics of the same infrastructures; they include the utilization of standard vocabularies and ontologies, linked data principles, RDF data representation, metadata enrichment, data interlinking, versioning and evolution of data, and alignment with industry standards for open data. In particular, in Table 4 we can see that the decentralized administration of Crete meets almost all these semantic metrics of the TSLO framework (6 out of 7), with the only exception of the utilization of standard vocabularies and ontologies. In Table 5 we can see the same metrics of the semantic

dimension of our TSLO framework for the four regional administrations: two of these four regional administrations meet none of these semantic metrics, while on the contrary Western Macedonia meets nearly all these semantic metrics (6 out of 7) followed by Attica meeting only one of the metrics. Therefore, there is a lower adoption of these semantic standards/specifications by the above regional administrations. The main deficiencies concern again the utilization of standard vocabularies and ontologies, the adoption of the linked data principles, the RDF data representation, the metadata enrichment, the data interlinking and the alignment with open data standards.

Finally, Table 6 shows these semantic dimension metrics for the eight municipalities: two of them meet none of these semantic metrics, and another one meets only one metric, while on the contrary another three, the Heraklion, Thessaloniki, and Trikkaia ones, comply with all the semantic metrics of the framework (7 out of 7), followed by Chalandri (5 out of 7) and Maleviziou (3 out of 7). The main deficiencies at the municipal level are the lack of RDF data representation, followed by the lack of data interlinking, linked data principles adoption and use of standard vocabularies and ontologies.

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Table 3: Technical dimension metrics for the municipalities' open data infrastructure

Technical metrics	Heraklion	Thessaloniki	Larissa	Maleviziou	Pa-tras	Rhodes	Trikkaia	Chalandri
Performance and Scalability	✓	✓	✕	✓	✕	✕	✓	✓
Integration with External Systems	✕	✕	✕	✕	✕	✕	✕	✕
Multi-language Support	✓	✓	✕	✕	✕	✕	✕	✕
Data Update Frequency	✓	✓	✓	✓	✓	✓	✓	✓
Data Visualization Tools (Limited)	✓	✓	✕	✕	✕	✕	✕	✓
Data Filtering and Search	✓	✓	✕	✓	✕	✓	✓	✓
Data Metadata (Limited)	✓	✓	✓	✓	✓	✓	✓	✓
Underlying OD CMS (CKAN, DKAN, Socrata, Custom, etc.)	✓	✓	✓	✓	✓	✓	✓	✓
Data Access Methods (Direct Download)	✓	✓	✓	✓	✓	✓	✓	✓
API Availability	✕	✓	✕	✕	✕	✕	✕	✕
Data Formats Supported (Up to 2 Star)	✓	✓	✓	✓	✓	✓	✓	✓
Thematic Categorization	✓	✓	✓	✓	✕	✓	✓	✓

Table 4: Semantic dimension metrics for the decentralized administration's open data infrastructure

Semantic Metrics	Crete
Alignment with Open Data Standards	✓
Versioning and Evolution of Data	✓
Data Interlinking	✓
Metadata Enrichment	✓
RDF Data Representation	✓
Linked Data Principles	✓
Use of Standard Vocabularies and Ontologies	✕

Table 5: Semantic dimension metrics for the regional administrations' open data infrastructure

Semantic Metrics	Attica	Central Greece	Western Macedonia	Ionian Islands
Alignment with Open Data Standards	✕	✕	✓	✕
Versioning and Evolution of Data	✓	✕	✓	✕
Data Interlinking	✕	✕	✓	✕
Metadata Enrichment	✕	✕	✓	✕
RDF Data Representation	✕	✕	✓	✕
Linked Data Principles	✕	✕	✓	✕
Use of Standard Vocabularies and Ontologies	✕	✕	✕	✕

5.3 Legal dimension

The legal dimension of our TSLO framework, which includes open data licensing, license compatibilities, data usage rights, and attribution rights metrics, aid in evaluating the legal interoperability of the same open data infrastructures. Tables 7, 8, and 9 illustrate how decentralized, regional, and municipal open data infrastructure adhere to these legal dimension metrics. In Table 7, where the results for the decentralized administration layer are presented, the open government data portal of Crete comply with all the metrics (4 out of 4) by providing proper information regarding open data licenses. These licenses are also compatible with the open data rules and regulations, and usage rights, as well as attribution rights, and are well-described on the portal. At the regional layer, as depicted in Table 8, open government data infrastructure of Attica and Western Macedonia regional administrations comply with the legal dimension metrics fully (4 out of 4). The Ionian Islands regional administration comply with most of them (3 out of 4), only lack license compatibility. On the contrary, Central Greece regional administration is not providing any information regarding these four important legal aspects on their open data infrastructure. In Table 9 we can see a clear 'polarization': out of the eight municipalities

Table 6: Semantic dimension metrics for the municipalities' open data infrastructure

Semantic Metrics	Heraklion	Thessaloniki	Maleviziou	Trikkaia	Chalandri	Larissa	Patras	Rhodes
Alignment with Open Data Standards	✓	✓	✓	✓	✓	✗	✓	✗
Versioning and Evolution of Data	✓	✓	✓	✓	✗	✗	✗	✗
Data Interlinking	✓	✓	✗	✓	✓	✗	✗	✗
Metadata Enrichment	✓	✓	✓	✓	✓	✗	✗	✗
RDF Data Representation	✓	✓	✗	✓	✗	✗	✗	✗
Linked Data Principles	✓	✓	✗	✓	✓	✗	✗	✗
Use of Standard Vocabularies and Ontologies	✓	✓	✗	✓	✓	✗	✗	✗

Table 7: Legal dimension metrics for the decentralized administration's open data infrastructure

Legal Metrics	Crete
Open Data Licensing	✓
License Compatibility	✓
Data Usage Rights	✓
Attribution Requirements	✓

that have open data portals, half (four) do not provide any information regarding the legal dimensions of the TLSO framework, while on the contrary the other four achieve a high level of compliance: the municipalities of Heraklion, Thessaloniki, and Chalandri fully comply with the legal metrics (4 out of 4), while the Maleviziou one (3 out of 4) lacks information only on open data licensing.

5.4 Organizational dimension

The organizational dimensions of the TSLO framework include four metrics data governance structure, data release policy, data publishing workflow, and data quality assurance metrics; these dimensions contribute to the better organizational interoperability of open data infrastructure, as described in section 3. Tables 10, 11, and 12 describe the compliance of decentralized, regional, and municipal open data infrastructure, respectively, with these organizational dimension metrics. At the decentralized administration layer, the Crete open data portal fully complies with the organizational dimension metrics (4 out of 4) as shown in Table 10. At the regional administration layer, as portrayed in Table 11, Attica fully complies (4 out of 4) with the organizational metrics, while Western Macedonia complies with most of them (3 out of 4) and the Ionian Islands comply with half of them (2 out of 4). The main deficiencies are the lack of data quality assurance, which is common in both, and the lack of data governance structure for the Ionian Islands. Finally, the Central Greece open data portal does not comply with any of the organizational dimension metrics. At the municipal level, as depicted in Table 12, Heraklion and Thessaloniki ones fully adhere (4 out of 4), followed by Trikkaia, Chalandri, and Rhodes having only one deficiency in data quality assurance (3 out of 4). On the contrary, two municipalities comply with only one metric, and one municipality does not comply with any of the organizational dimension metrics: the Maleviziou and Larissa ones (with only 1 out of 4), which in addition to data quality assurance, have deficiencies in data governance structure and data release policy. Finally, the municipality of Patras does not meet any of the organizational dimension metrics.

Table 8: Legal dimension metrics for the regional administrations' open data infrastructure

Legal Metrics	Attica	Western Macedonia	Ionian Islands	Central Greece
Open Data Licensing	✓	✓	✓	✗
License Compatibility	✓	✓	✗	✗
Data Usage Rights	✓	✓	✓	✗
Attribution Requirements	✓	✓	✓	✗

Table 9: Legal dimension metrics for the municipalities' open data infrastructure

Legal Metrics	Heraklion	Thessaloniki	Maleviziou	Trikkaia	Chalandri	Larissa	Patras	Rhodes
Open Data Licensing	✓	✓	✗	✗	✓	✗	✗	✗
License Compatibility	✓	✓	✓	✗	✓	✗	✗	✗
Data Usage Rights	✓	✓	✓	✗	✓	✗	✗	✗
Attribution Requirements	✓	✓	✓	✗	✓	✗	✗	✗

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Table 10: Organizational dimension metrics for the decentralized administration's open data infrastructure

Organizational Metrics	Crete
Data Governance Structure	✓
Data Release Policy	✓
Data Publishing Workflow	✓
Data Quality Assurance	✓

6 DISCUSSION

A notable disparity in data opening and sharing practices among local administrations is evident, with only a minority having a dedicated infrastructure for this purpose; furthermore, there is a lack of homogeneity between the open data portals and websites of the few local government portals, as only part of them are meeting the basic technological, semantic, legal and organizational requirements, and most of them are exhibiting significant deficiencies, especially concerning the semantic and the legal dimensions. These disparities pose substantial challenges to the combined exploitation of open data from large numbers of local government organizations (which would allow the generation of substantial social and economic value, as the value that can be generated from the use of open data from only one local government organizations is limited), and therefore to the development of cohesive and comprehensive open data ecosystems for this purpose. Particularly, only a small group of local governments distinguishes itself by actively engaging in the sharing of data; furthermore, only a sub-group of them do this by following the Creative Commons Attribution 4.0 license and complying with directives issued by the European Union.

A possible reason for this low participation of the Greek local government organizations in the open data movement is the two important economic crises that Greece experienced during the previous decade; the serious and long recessionary economic crisis in the period 2010-2018, followed by the COVID crisis in the period 2020-2023. The first of these crises resulted in a severe decrease in the available financial resources in all Greek public organizations, especially in the local government ones, which reduced their ICT budgets. Furthermore, these reduced ICT budgets had to be used mainly for the development of internal information systems in public organizations, which support their complex internal processes and increase their efficiencies (as this was imperative for coping with the crisis). The second of these crises necessitated the rapid development of e-services for citizens and firms, which enable them to conduct electronically (through the Internet) their transactions with public organizations, to reduce face-to-face contact and the spread of COVID that might result from them; so, this was the main ICT-related priority for public organizations during the COVID period. The above reduced the available financial as well as human resources for the opening of government data.

However, the variety in commitment to and participation in the open data movement observed among local administrations emphasizes the necessity of further investigating the factors that influence these varied approaches. Understanding the barriers and enablers affecting local open data initiatives is critical for enhancing broader participation in and implementation of government data

opening. This insight is essential for developing strategies that effectively address these challenges.

Furthermore, the results shed light on the potential for augmenting public engagement within the open data ecosystem. Enhancing the functionality of existing local open data portals and websites could include addressing the abovementioned deficiencies at the technological, semantic, legal and organizational level that were identified by our analysis (especially the semantic and legal ones), as well as integrating features that empower citizens to actively participate in data discovery (findability), analysis, and feedback provision. This could involve incorporating interactive data visualizations, collaborative data exploration platforms, and mechanisms for citizen-driven data requests.

Results demonstrate the relevance of frameworks, such as the TSLO framework described in this paper, in advocating the implementation of open data policies by presenting the strengths and weaknesses in the implementation of OGD strategies. They also highlight the necessity of technological infrastructure transfers, the adoption of standardized protocols, and the inclusion of features from other open government data sources. Additionally, the establishment of training and discussion forums, alongside the standardization of open data infrastructure development, are crucial steps toward fostering a robust, interconnected, and citizen-centric open data ecosystem at the local level. This focus on specific areas offers a path forward in contributing to the development of a more dynamic and participatory open data landscape within Greek municipalities. This study aimed for clarity by focusing on open data and its associated information and resources across different administrative levels. It's crucial to emphasize that any general data, information, or resources not directly or indirectly linked to open data were excluded from the TSLO framework.

7 CONCLUSION

Local government, as it has direct contact and transaction with citizens and firms, possesses valuable social and economic data; a significant part of them can be very useful to society and the economy. If they are opened, they can be exploited in various ways and lead to the generation of significant social and economic value. However, this requires a large number of local government organizations to provide large quantities of open government data, and at the same time these data to have a high level of homogeneity and interoperability, which enables the combined exploitation of them; this will be the determining factor for the development of comprehensive ecosystems, which include all the required actors for the combined exploitation of these data, and will pave the way for the generation of high levels of social and economic value from them.

In this direction in this paper initially is presented a framework named TSLO (technical, semantic, legal, and organizational) for evaluating the interoperability of open government data infrastructures of local government organizations. Instead of using open data indices like the Open Data Barometer (ODB), Open Data Inventory (ODIN), and the Global Open Data Index (GODI)10 focused on how accessible and transparent datasets are, the TSLO focuses on open data provision infrastructure capabilities. The TSLO framework includes four evaluation dimensions (technical, semantic, legal,

Table 11: Organizational dimension metrics for the regional administrations' open data infrastructure

Organizational Metrics	Attica	Central Greece	Western Macedonia	Ionian Islands
Data Governance Structure	✓	✗	✓	✗
Data Release Policy	✓	✗	✓	✓
Data Publishing Workflow	✓	✗	✓	✓
Data Quality Assurance	✓	✗	✗	✗

Table 12: Organizational dimension metrics for the municipalities' open data infrastructure

Organizational Metrics	Heraklion	Thessaloniki	Maleviziou	Trikkaia	Chalandri	Larissa	Patras	Rhodes
Data Governance Structure	✓	✓	✗	✓	✓	✗	✗	✓
Data Release Policy	✓	✓	✗	✓	✓	✗	✗	✓
Data Publishing Workflow	✓	✓	✓	✓	✓	✓	✗	✓
Data Quality Assurance	✓	✓	✗	✗	✗	✗	✗	✗

and organizational), and each of them provides several metrics for evaluating open data portals and websites.

Utilizing the above framework, we effectively investigated, analyzed, and outlined the advancements and limitations of various open government data infrastructure across the three local administration levels (decentralized, regional, and municipal) of Greece. The findings of this study reveal that only a minority of Greek local government organizations have open data portals or websites, and also that there is a lack of homogeneity and interoperability among them, with only a small part of them meeting the basic technological, semantic, legal, and organizational requirements; this highlights the importance of ongoing efforts to strengthen and standardize open data practices in Greek local governments.

This first application of the TSLO framework suggests that an automated evaluation tool based on it should be developed to overcome the issues that have been highlighted. Additionally, it is important to proceed to the use of the TSLO framework for a comprehensive evaluation of open data infrastructures of local government organizations across a variety of countries with different levels of technological and economic development. Finally, it is necessary to investigate the factors affecting positively and negatively the 'quantity' and the 'quality' of data opening by local government organizations, which on one hand possess valuable data that would be quite useful if opened to the society and the economy, but on the other hand have less financial and human resources for this purpose in comparison with the central government organizations (e.g. ministries).

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