A Network, Content, and Sentiment Analysis of Tweets about the Greek Ministries

IORDANIS KOTZAIVAZOGLOU[1], IOANNA PECHLIVANAKI[1], DIMITRIOS KYDROS[2], VASILIKI VRANA[1]
[1]Department of Business Administration,
International Hellenic University,
Terma Magnisias, 62124, Serres,
GREECE

[2]Department of Economic Sciences,
International Hellenic University,
Terma Magnisias, 62124, Serres,
GREECE

Abstract: - Twitter has been widely acknowledged as a crucial platform for political communication and deliberation. In this sense, research on information extraction from Twitter is growing rapidly but usually uses sentiment analysis in various aspects. The purpose of this study is to examine the networks of Twitter interactions among formal and informal political actors, as well as to identify the key topics of discussion and the sentiments conveyed by users about the 19 Greek ministries, by proposing a combination of three methods that includes not only sentiment, but also social network and content analysis. The research findings showed that not all ministries receive equal attention, resulting in interesting differences among them. Such a study can provide insights into the public's views, reactions, and concerns, and may help governments and/or ministries better understand and align their policies and communication with them. In addition, the proposed framework offers a multifaceted exploration of Twitter interactions, discussions, and sentiments that may be applied virtually in every large-scale, public or private organization.

Key-Words: Greek ministries, Twitter, political actors, social network analysis, content analysis, sentiment analysis, centrality metrics

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1 Introduction

Twitter, a very well-known and popular social media platform, has been rebranded as X since late July 2023 (in the following, we will use the term Twitter to refer to this platform). Twitter facilitates political communication and promotes deliberation between organizations and their stakeholders, [1], [2]. It has become a crucial tool for participatory democracy, [3], as it enables formal and informal political actors to engage in frequent, interactive, and efficient communication. Formal political actors are organizations or institutions that can directly influence political decisions, [4]. On the other hand, informal political actors, including regular people involved in online political discussions, actively utilize Twitter to share opinions, create social networks, and encourage political expression and deliberation, [5].

Since millions of users are active daily on Twitter, it is considered to be a valuable source of data. Since most user profiles, including those of organizations, are open to the public, it is easy to analyze users without concerns about their consent. Furthermore, since all communication is unmediated and interactive, it is relatively easy for researchers to study the interactions and discussions of Twitter users, gaining insights into their views and feelings, [6], [7], [8].

The role of political actors on online platforms, such as (and especially) Twitter, has gained a growing interest among researchers in the field of political communication. Major topics of discussion include the power of digital political actors to influence and shape the political sphere, [9], [10], or the increasing use of social media platforms, including Twitter, by organizations, [11], [12], [13], and ministries, [14], [15], to engage with their

stakeholders and establish relationships. Finally, the study of networks within Twitter has gained attention from the research community, [16].

While there has been some research on the use of social media by organizations in general, there remains a need for further investigation into the specific context of ministries as public organizations and their use of social media for political communication. Limited research has been conducted on this topic, as evidenced by the scarcity of studies on ministries in countries such as Greece, which could provide valuable insights into the field of social networking analysis and political communication, [14], [17], [18], [19]. Exploring the networks of users associated with ministries in Greece or similar countries with comparable public sector organizations could contribute significantly to the academic discourse on this subject. Due to its relatively under-researched nature, Greece presents a valuable opportunity for scholars to enhance the comprehension of the interplay between social media and political communication in the public sector. By focusing on Greece as a case study, researchers can delve into unexplored areas and generate new insights that can broaden the understanding of this topic. To our knowledge, no research has been done to deal not only with Greece but also with foreign ministries or government departments.

The paper represents a preliminary effort to address the research gaps outlined above, with a particular focus on the Greek ministries as a case study. This study aims to investigate the networks of Twitter interactions among formal and informal political actors, as well as to identify the key topics of discussion and the sentiments expressed by users about the Greek ministries.

Even though there has been some research on Greek ministries and social media, very little attention has been paid to the rigorous analysis of social networking among political actors. Moreover, the country boasts over 700,000 Twitter users, [20]. In the last couple of years, the Greek ministries have faced a variety of challenges, including economic crises, heightened instability, high inflation, pandemics, tense international relationships, and upcoming elections, all of which have led to increased social media use, [21].

The examination of citizens' opinions has always been of interest to state institutions, particularly during times of crisis, when decision-makers rely on knowledge to make informed choices, [22], [23]. The study addresses this critical issue by leveraging Twitter data to conclude a vast pool of information. This approach provides a comprehensive and accurate overview of Greek citizens' attitudes toward their ministries and can be used by state institutions to inform decision-making processes. Therefore, it expands the field's scope theoretically, by proposing a holistic methodology that incorporates three methods, namely social network analysis, content analysis, and sentiment analysis, in contrast to previous studies on ministries, [14], [17], [18], [19], that adopt only one of these methods. Thus, it provides a valuable methodology, [24], with a well-rounded perspective that overcomes the limitations of employing only one method.

The study also has a useful practical contribution to the public sector. It can provide governments and/or ministries with valuable tools to better understand the role of the formal and informal political actors on Twitter, enhance their engagement with the public, align their policies and improve their interaction with the public, and navigate the complex terrain of digital political communication more effectively. Since Greece is a Western-style democratic country that has many common traits with countries with a similar political system, the insights derived from this study may be utilized not only by Greece but also by other countries' governments and/or ministries.

The paper addresses the following research questions:

- RQ1: What are the characteristics of the networks created for all 19 Greek ministries?
- RQ2: Who are the most important users regarding centrality in each Greek ministry’s network?
- RQ3: What are the most important topics of discussion among users?
- RQ4: What are the feelings (sentiments) expressed by users?

The paper continues with the literature review, where the relevant literature is highlighted to provide the study’s context and background. Then, a detailed description of the methodology is presented, including the research design, data collection methods, and statistical techniques used for analysis, followed by the presentation of the findings along with a detailed analysis and discussion of them. Corresponding visualizations are also provided to enhance understanding. The paper ends with the conclusions that underline the main points of the study, as well as its limitations and suggestions for future research.

2 Literature Review

2.1 The Role of Twitter in Political Communication and Discourse

Twitter, due to its interactive, interpersonal, and dialogic nature alongside its popularity, is considered a very important medium for organizations in their communication and interaction with their stakeholders, [25]. Organizations through their active Twitter account can interact directly with them, [26]. Twitter is an excellent example of a meeting place between formal and informal political actors. Informal political actors have the power to practically engage in, shape the public sphere, and express their opinions about organizations, [27], [28], bringing about a further democratization of politics, [10]. Twitter allows organizations to interact with users, and record their preferences and their opinions following a more direct two-way model of communication, where organizations as formal political actors (along with Ministers or politicians) react, respond, post, like, and share with their stakeholders in a continuous effort to build relations. Users as informal political actors are considered very important elements of the corporate identity of organizations, [29].

Studies about Twitter use by organizations as an efficient tool for political communication and deliberation are also plenty, but they mostly focus on organizations from large countries, [30], [31], [32], [33].

2.2 Twitter Network Analysis

Studying Twitter users' networks provides useful information about the type and size of these networks, as well as clues about users' characteristics, discussions, and feelings, [34], [35]. In this vein, [36], performed social network analysis and content analysis of the tweets sent by Indian politicians between 2019 and 2021 amid some significant events in India. They conclude that Twitter not only gives Indian political users new avenues for contact but also polarizes their online political discourse. The study, [37], looked inside the network of Twitter users and the dissemination of tweets on the Pension Plan policy in Indonesia. The networks of Twitter users that participate in the distribution of tweets have account backgrounds related to politicians, political parties, governments, online news media, actors, and cultural practitioners. The responsibilities that people play in political dialogues on Twitter were covered in the study of, [38], based on information gathered throughout three dates during the corruption trial of Brazilian president Lula. To determine the users' roles during the divisive talks, they combined social network analysis metrics and social capital. In their study, [39], aimed to determine which digital influencers have the greatest influence over political discourse on Twitter in Spain. The study's findings reveal that political and media elites have continued to strengthen their dominant positions as digital influencers.

2.3 Political Sentiment Analysis on Twitter

Several previous studies tried to investigate sentiments that users express about politics. Several approaches are used to extract sentiment from tweets, [40], [41]. Unsupervised methods rely on lexicons, lists of 'positive' and 'negative' keywords, or simply counting the frequency of each term to estimate sentiment based on the ratio of occurrence of two types of keywords concerning one another, [42]. More advanced approaches employ supervised learning techniques and prediction models, trained on either manually classified tweets or tweets with an emotional context, [43].

Sentiment analysis of real-world political campaigns is also especially interesting, because it aids in detecting patterns, understanding human behavior, and identifying generic approaches for analyzing user behavior in online social networks, [44], [45]. The study,[46], discussed the 2016 Austrian presidential elections. The study, [47], combined a lexical-based with a learning-based approach to form a hybrid approach to sentiment analysis. The study, [48], extracted tweets related to India's General Elections in 2019 was carried out in tandem with a study of sentiments among Twitter users toward the major national political parties participating in the electoral process. The study, [49], examined the sentiment on Twitter to ascertain the public's opinions before, during, and after the U.S. elections 2020 and compared them with their results. The findings show that, in most situations, the election results and the mood reflected on social media were in agreement.

The study, [50], examined how a sample of alt-right followers behaved before and after the US midterm elections in 2018, [51], used quantitative and qualitative approaches to examine more than 50,000 right-wing German hate tweets that were published during the 2017 German federal elections to provide insight on the situation in Germany. Most of the tweets are filled with hate speech, particularly toward immigrants, but also at politicians and other voters.

Previous studies have also studied Twitter users' sentiments on various political aspects. The study, [52], tried to understand the agenda set by the top European populist political party figures on Twitter, as well as their user engagement tactics. Findings indicated a low level of theme fragmentation, the introduction of suggestions rather than engaging voters, and the existence of a strong inverse relationship between the number of tweets produced and user interest. In a recent study, [53], investigated Donald Trump and Jokowi's sentiments on Twitter regarding Covid-19 policy dissemination. The outcome demonstrates that both Jokowi and Trump experienced more unfavorable than positive sentiments.

The study, [54], examined the Syrian war using sentiment analysis of tweets to determine how the sentiment forms the contemporary political scene and influences receiver knowledge. A training data set was utilized for sentiment analysis to glean insights into the tweets of various Syrian conflict sides. The findings demonstrated that there was a real conflict taking place on social media to affect people's emotions.

Although sentiment analysis has gained popularity in recent years, there remains a scarcity of studies analyzing sentiment in the context of ministries. For instance, [55], conducted a sentiment analysis on tweets to assess the public opinion of the Indonesian Ministry of Health's performance. Their findings indicated that the vast majority of tweets expressed negative sentiments.

3 Methodology

NodeXL Pro, an Excel template, was used to query Twitter API, find content relevant to the Greek ministries, and create networks of users. The official @username of each ministry's account was queried and other keywords were excluded due to the poor return of relevant data. All 19 ministries and their official @username on Twitter are listed in Table 1.

Table 1. Ministries and their corresponding official Twitter accounts

Ministries	@usernames
Greek Ministry of Finance	@minfingr
Greek Ministry of Development and Investments	@MinDevGR
Greek Ministry of Foreign Affairs	@GreeceMFA
Greek Ministry of National Defence	@Hellenic_MOD
Greek Ministry of Education and Religious Affairs	@MinEduGR
Greek Ministry of Labour and Social Affairs	@labourgovgr
Greek Ministry of Health	@YpYgGR
Greek Ministry of Environment & Energy	@YpenGr
Greek Ministry of Citizen Protection	@yptpgr
Greek Ministry of Climate Crisis and Civil Protection	@GSCP_GR
Greek Ministry of Culture and Sports	@cultureGR
Greek Ministry of Justice	@MinJustGR
Greek Ministry of Interior	@ypesgr
Greek Ministry of Migration & Asylum	@migrationgovgr
Greek Ministry of Tourism	@MinTourGR
Greek Ministry of Administrative Reform and Electronic Governance	@MinDigitalGr
Greek Ministry of Infrastructure and Transport	@ypomeofficial
Greek Ministry of Mercantile Marine and Island Policy	@naftilias
Greek Ministry of Rural Development and Food	@MinagricPress

All collected data span a period of seven to ten days, with the latest retrieval applied on 12 July 2022. It was selected as a representative period of the country with an intense political agenda. Due to restrictions enforced by the Twitter API, there are limitations on the volume and frequency of tweets that can be retrieved. The time period is chosen since it signifies the beginning of summer, a period largely occupied by a discussion on tourism and the relevant economic outcomes. This period can also be characterized as a typical and representative one from the political, economic, and social point of view. Specifically, issues such as the energy and economic crisis, the Greek-Turkish relations, the Russian-Ukraine war, and a new bill for tertiary education mainly occupied the then-public sphere.

Tweets are categorized into five types: 1) tweets, 2) retweets, 3) mentions, 4) mentions-in-retweets, and 5) replies. Tweets, mentions and replies can be subsumed under the label real content because they do not replicate already stated information. Real content is most frequently the basis for drawing conclusions, [34]. Retweets and mentions-in-

retweets are only included in calculating the size and volume of a ministry's network.

Each search procedure results in a network. Each user posting content with the keyword used automatically becomes a node in the network and develops relationships (edges) in the form of (re)tweets, mentions (in retweets), and replies. Networks resulting from Twitter data are directed, because the content is addressed to specific users.

Understanding the structure of a network is the point of Social Network Analysis (SNA), [56]. In the context of the study, finding who communicates with whom and how their ties develop, could shed some light on the perceived importance of each Greek Ministry. The networks created in this step further provide the starting point for the content and sentiment analysis that will follow.

Content analysis is a useful tool for discovering and organizing categories, themes, and meanings present within a text. Here, content analysis relies on word adjacencies or word pairs, [35], [57], to create networks of words (textual networks) neighboring each other within texts that are studied in terms of social network analytic techniques. SNA focuses not only on the frequency of words in a text but also deals with the positional properties of the words to conclude the main topics, the relationship between words, their proximity, and their coexistence in a text, [58].

Sentiment analysis uses language processing techniques to discover meanings, find the sentiment running through a text, and detect the public emotions of a tweet (whether it is positive, negative, expresses anger, etc.), [24]. A lexicon-based approach was used for detecting the sentiment of tweets in the networks because it has been proven sufficient in coverage and precision rates, [59].

In both content and sentiment analyses, the original data were filtered to perform relevant analyses on tweets, mentions, and replies. Data include tweets in many languages (Greek, English, Arabic, etc.), but the analysis focused only on Greek and partly English, since English ranks highest in usage on Twitter, [60]. English tweets were incorporated when they took up at least 20% of the total comments in a ministry's network. Wherever the percentage of tweets was beyond that threshold, another network was created only for English comments. The ministries eligible to be studied for English comments are listed in Table 2.

Greek tweets were studied using the lexicon developed by, [59], and English ones using the NRC Emotion Lexicon, [61]. In both cases, some preprocessing was done in raw data, such as stop-word removal, lemmatizing, etc. After this procedure, lists of word pairs were created for each ministry. These pairs were used to create new, semantic networks that are used for the content analysis.

Table 2. Percentage of Greek and English comments in some ministries

Ministries	Greek	English	Total	%Greek	%English
@GreeceMFA	1633	2815	5552	29.41%	50.70%
@labourgovgr	61	267	454	13.44%	58.81%
@cultureGR	61	454	550	11.09%	82.55%
@MinJustGR	10	12	22	45.45%	54.55%
@migrationgovgr	22	12	41	53.66%	29.27%
@MinDigitalGr	21	27	62	33.87%	43.55%
@MinTourGR	238	123	416	57.21%	29.57%

4 Results and Discussion

4.1 Overall Metrics of Networks

RQ1 investigates the characteristics of Greek Ministry networks. In Table 3, the ministries are presented ranked in descending order according to the total number of edges (relationships developed among its nodes).

Table 3. Overall size metrics of all networks

Ministries	Vertices	Unique Edges	Edges With Duplicates	Total Edges
@MinEduGR	402	2486	33938	36424
@GreeceMFA	2502	6461	8901	15362
@Hellenic_MOD	388	764	1140	1904
@GCSP_GR	408	918	902	1820
@YpYgGR	358	716	854	1570
@cultureGR	332	823	600	1423
@MinTourGR	303	817	271	1088
@MinDevGR	233	538	445	983
@labourgovgr	89	88	569	657
@YpenGr	95	211	156	367
@yptpgr	112	279	34	313
@naftilias	84	174	59	233
@ypesgr	59	151	39	190
@MinDigitalGr	40	95	20	115
@minfingr	33	59	45	104
@migrationgovgr	40	79	18	97
@MinagricPress	30	67	4	71
@ypomeofficial	22	31	6	37
@MinJustGR	20	22	0	22

As expected, not all Greek ministries draw equal interest. As evidenced by Table 3, the Ministries of

Education and Religious Affairs (@MinEduGR), Foreign Affairs (@GreeceMFA), National Defense (@Hellenic_MOD), Climate Crisis and Civil Protection (@GCSP_GR), Health (@YpYgGR and Culture and Sports (@cultureGR) are the ministries with the largest networks on Twitter, ranging from 1423 to 36424 total edges. As one moves down Table 3, users tend to interact less and less with the content presented.

Ranking in Table 3 generally also reflects the interests of the Greek public. It is only natural, for instance, to find the Ministry of Education and Religious Affairs on the top spot. Public education in Greece has undergone frequent changes in recent years, causing instability for both students and parents. The curriculum has been modified multiple times and exams have been restructured, necessitating rapid adaptation to new conditions, particularly for those in high school. The availability of teaching staff is a widely discussed issue, with substitute teachers needed each year to fill vacant positions. This problem is particularly acute in the summer when a surge of traffic is generated on Twitter as the selection of these teachers takes place, [62].

Equally expected is the appearance of the Ministry of Foreign Affairs and Ministry of Defense in the subsequent places. The geopolitical position of Greece often brings it face to face with national or supranational issues pertinent to national defense and security, energy, etc., [63]. The nation's defense discourse is strongly propagated across Greek society, considering that Greece sits in the Balkan region, where issues between neighboring states have yet to be resolved. It is only recently that Greece and Northern Macedonia have signed a treaty about the legal name of the latter; both countries faced significant backlash from within their territory, which was also mirrored in online activity, [64]. Sometimes such issues are so aggravated that they tread beyond political solutions and into the military domain. Airspace violations among countries in the region, for instance, are par for the course, [65], and sometimes escalate to armed altercations (e.g., the Kosovo War). All this justifies the extensive engagement on Twitter around those two ministries.

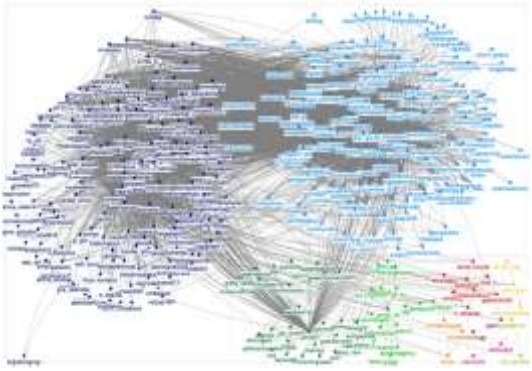
The Ministry of Climate Crisis and Civil Protection is next on the list. As per the ministry's official website, it is entrusted with the task of averting disasters of any nature and executing meticulous plans to curtail their impact, [66]. The ministry garnered public attention during the COVID-19 outbreak and has since been at the forefront, largely due to the ongoing health crisis. Additionally, with Greece experiencing annual wildfires and earthquakes, and the global issue of climate change, it is no surprise that the ministry's Twitter network is among the largest.

It is not a surprise to see that the Ministry of Health ranks fifth on the list of Twitter influencers. It should be remembered that at the time of our data-collection procedures, the COVID-19 pandemic crisis was active. However, some Greek-specific issues contributed to the ministry's significant presence. We detected discussions about the understaffing of the national health system which has been ongoing for years, even before the COVID-19 pandemic, which (reasonably) has raised a surge of interest in such issues, especially due to the increased need for healthcare workers. Strong criticism from the public towards the government for its handling of the crisis is present. One area of concern is the healthcare workers' contracts, which are often not renewed, further exacerbating the understaffing issue, [67]. Discussions on the lack of essential equipment and medication in Greek hospitals are not only present but have become a recurring topic in the public health system's problems.

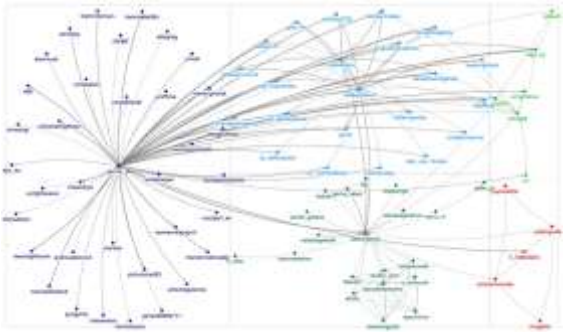
In the last position of the 'big' networks, we see the Ministry of Culture and Sports. This fact is not a surprise, since the Greek ancient civilization,'s remains in buildings and museums are a common topic in discussions at all levels, since not only the modern Greek national identity has been linked with the ancient world, but also the plethora of museums, ancient locations, etc., play an important role to the economic life through tourism. During the time period of our data collection, a large proportion of the discussions were talking about the repatriation of the Parthenon Marbles, which are currently being displayed in the British Museum. The question of whether these ancient treasures should be returned to Greece has been a hot topic for more than 30 years, [68], and now online platforms, such as Twitter, are adding a new dimension to the debate. The issue of cultural property and its connection to Greek national identity has long been a matter of public concern and this is no less true in the era of social media. Greek culture is particularly fascinating, because it extends far beyond the borders of Greece itself, capturing the interest of people from around the world.

Some visualizations of these networks are presented in Figure 1. Examples include one large network of the Ministry of Education and Religious Affairs in Figure 1(a), a smaller one of the Ministry of Labor in Figure 1(b), and one very small

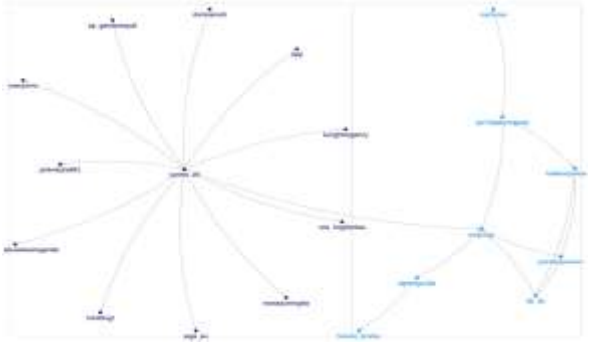
network, that of the Ministry of Justice in Figure 1(c).



(a) The Ministry of Education and Religious Affairs Network



(b) The Ministry of Labor Network



(c) the Ministry of Justice Network

Fig. 1: Three different-sized networks. Lots of users interact with the Ministry of Education, but very few know about the Ministry of Labor

4.2 Types of Tweets

Another important observation about networks concerns the different types of tweets for all 19 Greek ministries' networks. Types of content are tweets, retweets, mentions, mentions-in-retweets, and replies. In Figure 2, the percentage of each type of content for each ministry's network is presented, using color coding to make distinctions comprehensible.

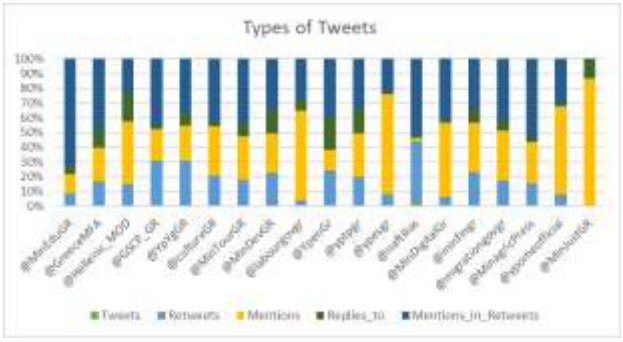


Fig. 2: Types of Tweets for each Greek Ministry

Plain tweets are the type least appearing in Figure 2 and mentions-in-retweets are generally the type with the most widespread presence. Data seem to suggest that information on social networks is spread mainly through retweets (mentions-in-retweets are also essentially retweets) and mentions. It is noteworthy that almost always users refer to another actor by way of @username convention or take a stance toward something somebody else has said through reposting that content. Retweeting means users find value in a post and want to share it, effectively leveraging the ideas of people they deem important. Opinion sharing becomes easier by mentioning someone or retweeting a post, [69]. However, other researchers have questioned such an approach and proposed different procedures (see our discussion on content and sentiment analysis).

4.3 Vertex Level Metrics

This section focuses on the vertices and more specifically goes over the following centrality metrics: in-degree, out-degree, and betweenness centrality. In and Out degree centrality metrics count the number of connections a vertex creates within the network. In-degree represents the number of edges other vertices have formed toward a vertex; in other words, it is the number of edges where the arrow points to the user. It shows how engaged the community is with the specific vertex. Out-degree centrality represents the number of edges a vertex has formed toward other vertices, which translates into the number of edges where the arrow points outward to other users. High out-degree centrality means that a vertex has tweeted a lot wanting to reach other users in the network. Out-degree centrality shows how prominent or actively engaged a user is, respectively.

Betweenness centrality is a metric that examines how many times a node lies in the shortest path to other nodes, or else to what extent a user acts as a bridge to other users. High betweenness centrality means that many users depend on a specific vertex to relate to others, [70]. That specific vertex better

controls the distribution of information, [56], [71]. In this case, users with high betweenness centrality could be serving as bridges to users that might otherwise not have direct communication with respect to their interest in the Greek ministries.

In this phase of the research, an analysis was conducted to identify the top ten vertices in each Greek Ministry network based on in- and out-degree, as well as betweenness centrality. Subsequently, the accounts were accessed by each user to discern whether they were formal or informal political actors. Distinguishing between personal and business Twitter profiles was a challenging task, as the platform allows anyone to create an account and post personal information voluntarily. This made it necessary to inspect many profiles manually to ensure accurate categorization.

Due to the nature of the data, formal political actors were split into formal individuals (people) and formal organizations (government institutions). If a user is a minister, a statesman, or a politician we consider him a formal political actor, of the individual type. Ministries, political parties, municipalities, research centers, institutes, federations, Universities, museums that belong to the state, etc., are considered formal political actors, of the organization type.

Similarly, informal political actors are split into individuals and organizations. Everyday users that are not professionally involved in politics are considered informal political actors, of the individual type. NGOs, private companies, private professional associations, movements, etc., are considered informal political actors, of the organization type. There is finally a third category that includes all organizations and individuals related to the media (e.g., journalists).

Figure 3 shows the total percentage of formal and informal political actors, and the media for the in-degree centrality metric. The distribution of inward-looking edges is not even: formal political actors rank higher in this metric. On average, 73% of tweets are targeted toward formal political actors. We consider such an outcome reasonable because informal political actors (and media) usually respond to what formal political actors have to say and not the other way around. Vertices with high in-degree most often turn out to be ministers and/or substitute ministers (e.g., @sofiazacharaki, @tsiaras_kostas, @ nikosdendias, @ g_plakiotakis), state politicians (e.g., @ spiliosl, @ kyranakis etc.), and the Prime Minister (@primeministergr) etc.

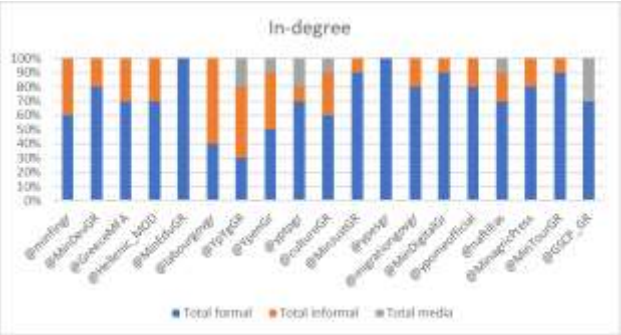


Fig. 3: In-degree distribution of user types

The exact opposite is the case of out-degree centrality. Figure 4 shows the total percentage of formal and informal political actors, as well as media in terms of the out-degree centrality metric. The distribution of formal, informal, and media actors is visible. Edges starting from informal political actor vertices and looking outward are overwhelmingly more than those starting from formal political actors (or media). In some cases, they reach percentages as high as 100% and are over 80% most of the time. The data therefore confirm that social media have indeed provided a platform for engagement and a stepping-stone to co-creating the public sphere, [27].

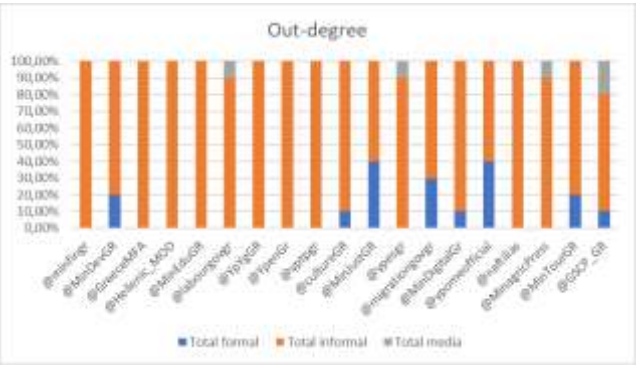


Fig. 4: Out-degree distribution of user types

Results in betweenness centrality are similar to out-degree centrality. Informal political actors score higher than formal ones in terms of their ability to mediate between further users and let information reach larger audiences. This finding might be explained as the informal political actors are the best ranking category in out-degree centrality. They spread the information, mostly address formal political actor nodes, and create communities with their extended engagement. Figure 5 shows betweenness centrality both for formal and informal political actors and media.

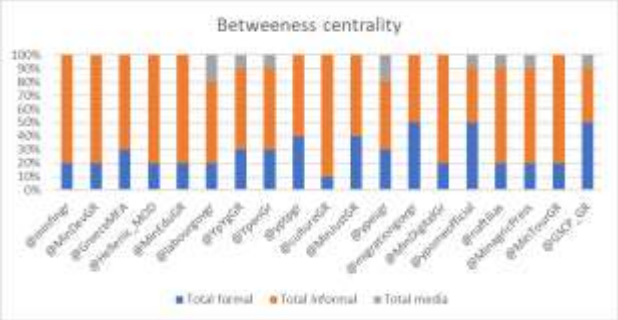


Figure 5: Betweenness centrality distribution of user types

4.4 Content Analysis

Content analysis is carried out on real content to answer RQ3. Figure 6 shows a comparison of real content percentages across tweet types. Ministries are ranked in descending order according to the percentage of real content in the network. As already seen, not all networks are equal in terms of size and this also applies to real content; however, the ranking according to real content is different from that of overall content. Real content is essential in finding the real word pairs and the sentiment in comments that is not just a reproduction (as in retweets for example).

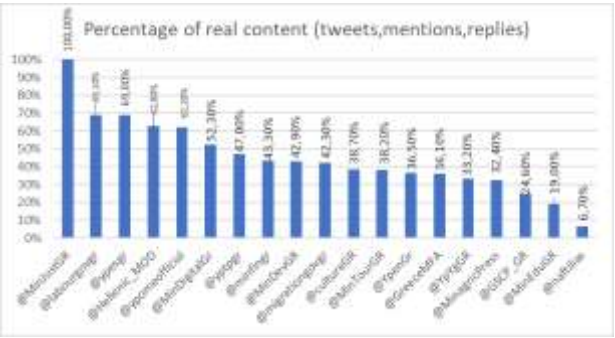


Fig. 6: Percentage of real content

Adjacent words (word pairs) form a pair of connected nodes. Each ministry's network is created taking into consideration its size. In small networks, all word pairs are included. In larger networks, word pairs that appear over 10 times were included due to space constraints.

Both English and Greek networks were examined (Greek word pairs are translated into English). Only the Ministries of Justice (@MinJustGR), Administrative Reform and Electronic Governance (@MinDigitalGr), and Migration & Asylum (@migrationgovgr) have no word pairs available after all the preprocessing previously described. This is surprising considering that @MinJustGR ranks highest in real content. A possible explanation lies in the proportional nature of the data. When a network has very few total edges (@MinJustGR with 22 edges ranks lowest in that respect), it also has fewer types of tweets (@MinJustGR has only mentions and replies). This is why the largest networks are presented in terms of total node count: those networks also have the largest pool of real content in absolute numbers. Accordingly, the two largest English networks are visualized in terms of the number of English tweets: @GreeceMFA and @CultureGR.

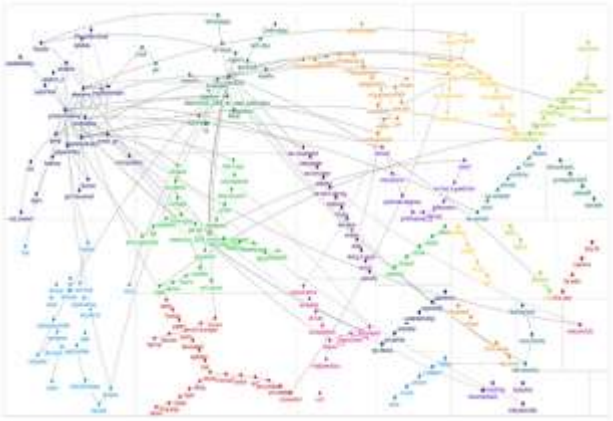


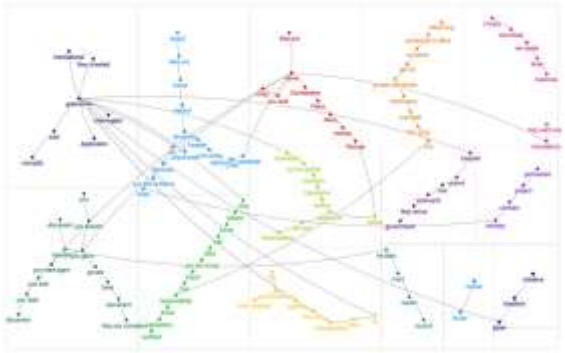
Fig. 7: MineduGR word-pairs network

The first network presented (Figure 7) is the Ministry of Education. Talks about ASEP (a state institution that holds at certain intervals written exams when the state needs employees in the public sector) of 2008 generally take up most of the discussions within this ministry's network. Such an exam was carried out in 2008 and some people who succeeded back then are still waiting to be appointed. This issue concerns @MineduGR because permanent teaching positions are normally handed out through this ASEP exam. People are raising their voices for meritocracy and equal opportunities.

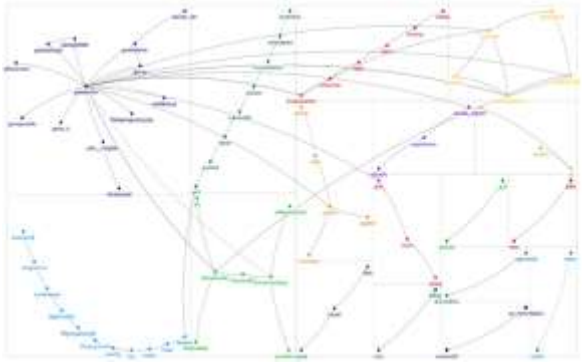
In Figure 8(a), the Greek content from the Ministry of Foreign Affairs is presented. The @GreeceMFA Twitter handle features conversations centered around corruption, particularly in relation to the Novartis scandal, which involves allegations of government officials accepting bribes to promote a pharmaceutical company. Users mention the names of officials involved in the scandal and discuss issues related to the translation of specific documents. The discussion spans various topics, covering different aspects of the situation and extending throughout the entire semantic network.

In Figure 8(b), it is noticeable that the discussion among the individuals does not revolve around internal Greek issues. This is understandable as

most of them are not native Greek citizens. Instead, they express concerns about the slow visa issuance process, which hinders their ability to stay in Greece. Additionally, the conversation shifts towards the ongoing Tigray conflict in Ethiopia (November 2020-November 2022). Several individuals in the network highlight the urgent need for the international community to provide humanitarian aid to those affected by the conflict.



(a) Greek content



(b) English content

Fig. 8: The Ministry of Foreign Affairs, Greek (a) and English (b) word-pairs networks

Figure 9 presents the Greek word networks related to the Ministry of Defense, highlighting key topics discussed within these networks. These include Greek international relations with a particular focus on military affairs, such as the ongoing tensions with Turkey and frequent airspace violations in the Aegean region. Additionally, the need for providing aid to Ukraine in the form of military or humanitarian materials is also mentioned. Notably, an interstate agreement between Greece and Germany has been established, which involves the exchange of older military vehicles from Greece to Ukraine, to be replaced by modern ones provided by Germany. This agreement is especially relevant to the aforementioned humanitarian efforts.

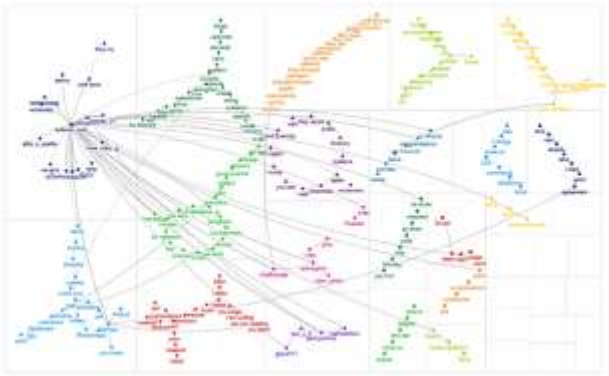


Fig. 9: The Ministry of Defense word-pairs network

Finally, Figure 10 presents the semantic network of tweets related to the Ministry of Culture, which focuses on English tweets as they were more numerous than the relevant Greek ones. The network analysis shows that @cultureGR users are primarily concerned with the Parthenon marbles, which remain in the British Museum despite being part of Greek cultural heritage. The users express a strong desire for the marbles to be returned to their "ancient" home, reflecting a larger ongoing debate about cultural repatriation.

Fig. 10: The Ministry of Culture English word-pairs network

4.5 Sentiment Analysis

RQ4 aims to analyze the sentiments expressed by users in the context of each ministry network. The sentiment analysis is conducted on Greek comments, which are categorized as either positive or negative in terms of their polarity. The results of this analysis are presented in the figures below. In Figure 11, positive comments are presented in blue and negative in orange. The negative comments are more than the positive ones. Most actors post comments expressing a general negativity toward the ministries. The available data suggests that users may not be as satisfied with the Greek ministries, as positive comments appear to be less common. This trend appears to be consistent across all 18 ministries, except @MinDigitalGr, for which no

data is available due to the process of removing non-real content and implementing a lexicon-based sentiment analysis. Given this pervasive negativity, it may be worthwhile for officials to investigate further to identify the underlying causes and potential areas for improvement.

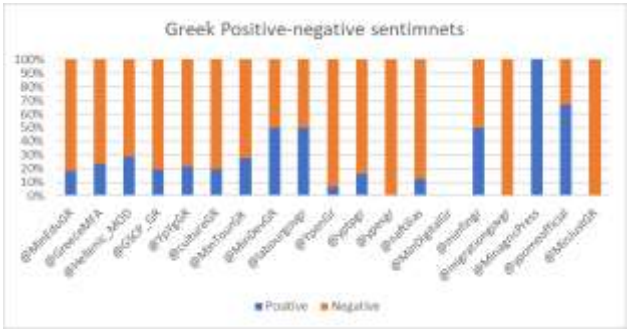


Fig. 11: Positive and negative sentiments

For a more detailed presentation of the general feelings of actors, sentiments are classified (anger, disgust, fear, sadness, happiness, and surprise) in Figure 12. Anger, disgust, and fear take up the largest percentages overall. The sentiment of surprise has a great percentage because both positive and negative words could belong in this category. The general negativity expressed by users might be chalked up to the fact that people have to deal with unprecedented circumstances and therefore harsh political decisions on the ministries' part. Other studies have also noted such overarching negativity in Greek Twitter, [72], which might point to a broad dissatisfaction of the Greek public toward government organizations.

One could make the case that there is misrepresentation of political voices on Twitter which would lead to skewed results. For instance, it has been found that Twitter users in the US are more likely to be Democrats compared to the average US adult, [73], with obvious implications as to the sentiment they express in their tweets; the differences between the two groups are not limited to political views, but span a broad range of demographics or ideological stances without however being overly pronounced (ibid.). Intuitively speaking, similar discrepancies also appear in the Greek case, but not to the extent that they create a distorted picture of the general public's sentiment.

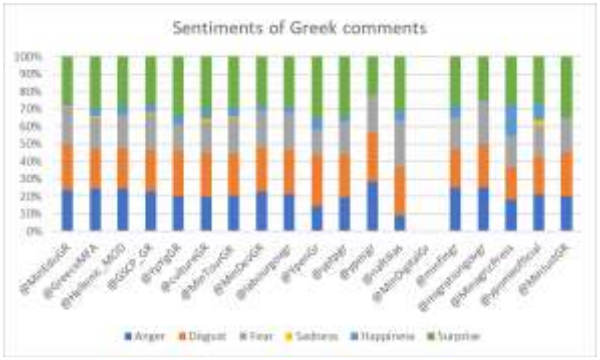


Fig. 12: Sentiment in greater detail

Figure 13 presents the polarity of the English comments.

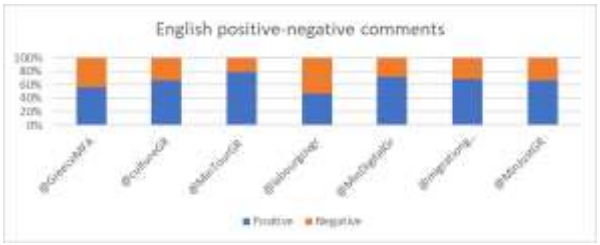


Fig. 13: English positive-negative comments

The distribution differs from the Greek comments. Within the English comments, positive and negative sentiments are similarly distributed in the ministries' networks. There appears to be a notable difference in the sentiment expressed in posts written in English versus those written in Greek. Specifically, posts written in Greek by users who are experiencing the daily realities of Greek life tend to express a general sense of dissatisfaction and negativity towards the ministries and their policies. However, posts written in English by users who may not necessarily be Greek seem to view the situation in a less negative light.

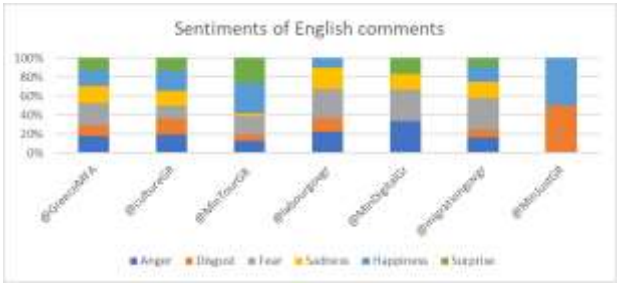


Fig. 14: Sentiments of English comments

Based on the data presented in Figure 14, it appears that sentiments expressed in English-language posts are more evenly distributed compared to those expressed in posts written in Greek. The sentiments expressed by Greek users appear to be more varied and are primarily

characterized by negative emotions such as anger, desperation, and fear about their future and lives in relation to Greece's public sector. By contrast, English-language posts suggest a wider range of emotions and do not seem to point to a clear potential sentiment.

5 Conclusions and Implications

The rise in social media usage has compelled government ministries to create their profiles to better engage with citizens, promote their policies, and disseminate messages rapidly to a broad audience. Twitter is particularly useful for citizens to express their opinions and discuss government policies. The platform also produces vast amounts of text, [74], with political insights that can be analyzed to gauge public opinion, understand citizens' political sentiment, and forecast future trends. Twitter's unmediated communication capabilities allow ministries to communicate directly with the general public, rather than relying on the elites who control mainstream media. However, research on ministries and their networks on social media is limited.

This article seeks to address this gap by proposing a framework to examine Twitter interactions among formal and informal political actors in the Greek ministries. [75]. The studies, [76], [77], highlighted the need to integrate social network analysis with other qualitative methods for gaining a more comprehensive and deeper understating of social phenomena. Thus, this paper adopts a more holistic framework for studying Twitter interactions among formal and informal political actors and gains deeper insights into the complex landscape of the Greek Ministries and the discussions surrounding them on Twitter. The framework aims to identify the major topics of discussion and the sentiments expressed by users. By examining typical networks and discussions formed around ministries during ordinary periods, this article can provide valuable insights into political communication. The proposed framework offers a multifaceted investigation of Twitter interactions and can be applied to virtually any case where a researcher needs to explore the general discussions and sentiments about a large-scale, public, or private organization.

The study investigated the characteristics of Twitter networks related to the 19 Greek ministries and found that not all ministries receive equal attention. Specifically, the Ministries of Education and Religious, Foreign Affairs, National Defense, Climate Crisis and Civil Protection, Health, and Culture and Sports are more frequently mentioned on Twitter. This information can provide insights into the interests, issues, concerns, and reactions of the public or specific groups in the Greek context. Thus, it is crucial not only for governments, but also for specific ministries to understand these preferences to better align goals, policies, and priorities with the needs and views of the public, or adjust their communication accordingly.

Given that Twitter opinions and comments can be considered an expression of activated public opinion, these findings can be useful for governments to better understand the public and prioritize targets and policies based on unbiased opinions and concerns. However, the study also revealed that not all ministries take full advantage of Twitter to engage citizens effectively, which is essential at a time when public confidence in the government is dwindling.

To effectively engage with the public, ministries should monitor and evaluate the impact of their Twitter activity. It is essential to identify Twitter accounts that perform well, as they have the greatest influence on public perception and can serve as examples for less prominent ministries to learn from. By adapting and learning from each other, ministries can shape their Twitter communication strategies to enhance public value creation. Twitter makes it easy to share opinions by mentioning or retweeting others, [70], creating communities of users who may be formal or informal political actors.

The study examines the centrality of vertices in a network to identify the most influential formal and informal political actors. Formal political actors, including ministries, have a high in-degree centrality rate, indicating that they receive many comments and have a significant impact on engaging the public. This finding aligns with the research conducted by, [37], which revealed that accounts actively involved in disseminating tweets on Twitter mainly consist of formal political actors. They are critical in establishing credibility, building trust, and promoting transparency for the ministry. Identifying these prominent accounts is also useful for less prominent Twitter accounts that can attract readers' interest by responding to them with a unique perspective or valuable information. Additionally, media outlets can scan these prominent accounts to obtain a "summary statistic" on the distribution of viewpoints on a particular political issue.

Informal political actors, on the other hand, have high out-degree and betweenness centrality rates, indicating that they play a bridging role in

disseminating information. Accounts with high betweenness centrality have the power to direct information flow and can demonstrate their expertise by sharing ideas with others, [75]. This finding suggests that informal political actors can be equally influential in shaping public opinion, and media outlets should also consider their opinions in reporting on political issues. The study, [78], also found that informal political actors have great influence. In summary, the study highlights the importance of both formal and informal political actors in shaping public opinion and emphasizes the need for media outlets to consider a diverse range of perspectives when reporting on political issues.

The last section of the study focuses on the most frequent discussions among users and the sentiments they express when they post a Tweet. Greek comments generally express negativity toward all 19 Greek ministries. Citizen sentiment analysis is the "new eye of government", [79]. Feelings and opinions of the public can act as a barometer, that reflects the nation's state of affairs, problems, and citizens' expectations. Moreover, discovering unfavorable public opinions and concerns could offer helpful input to pinpoint problematic policies and improve them to handle any emerging tensions between the public and ministries. The knowledge and understanding of public sentiments allow governments and ministries to make decisions that will guide and control government management. The sentiments expressed by Greek users on Twitter appear to be more strongly negative than those expressed by English users. This may be because Greek users have firsthand experience of the country's recent years of instability, high inflation, pandemic, tense international relationships, elections, and economic, social, and geopolitical crises, [21]. Examining Twitter data can help ministries gain a better understanding of how the public feels about these events, identify sensitive information, pinpoint areas of public concern, and gauge general sentiment. By doing so, the ministries can take prompt and effective action to offer emotional support, particularly in today's turbulent environment.

The proposed framework provides valuable insights that ministries can use to develop plans for government action. By continuously tracking public opinion, ministries can identify evolving trends and handle problems before they become crises. Acknowledgment of public sentiment and its inclusion into the decision-making process could strengthen the relationship of ministries with citizens, deepen democracy, and create more stable societies.

6 Limitations and Suggestions for Further Research

The study has some limitations that could be addressed in future research. Firstly, the examination of the ministries was limited to a short timeframe, which may limit the generalizability of the findings. To overcome this limitation, future research could choose data samples with a broader time horizon, allowing for a more comprehensive understanding of the use of Twitter by ministries.

Secondly, the study was limited to the Greek ministries, which may restrict the applicability of the findings to countries with severely different political, social, or communicational contexts. To address this limitation, future research could include public institutions and ministries from these countries, facilitating comparative research that could provide more extensive insights.

Thirdly, the study focused solely on political Twitter exchanges, and it would be interesting to expand the scope to include other public organizations at the municipality or community level. Additionally, studying how organizations from other countries use Twitter to engage with their stakeholders could provide insights into cross-cultural differences in the use of Twitter.

Finally, replication of the proposed framework could be beneficial in advancing the under-studied topic of ministries on Twitter. This could help improve the proposed framework and provide further insights into how ministries use Twitter for public engagement.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

- Iordanis Kotzaivazoglou and Ioanna Pechlivanaki carried out Conceptualization.
- Dimitrios Kydros is responsible for data curation.
- Dimitrios Kydros and Ioanna Pechlivanaki carried out data curation and implemented formal analysis, methodology, and visualization.
- Iordanis Kotzaivazoglou, Ioanna Pechlivanaki Dimitrios Kydros, and Vasiliki Vrana were responsible for writing - the original draft and writing - review & editing.

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