

Interuniversity Doctoral Programme in Urban and Regional Development

Social media ecosystem and disinformation. The dynamics of the debate on nuclear energy, radioactive waste and the atomic conflict narrative.

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Introduction

This work is inspired by an original curiosity to understand what dynamics in the online environment facilitate/lure people to adopt extreme perspectives, believe in conspiracy theories, and rely on alternative channels of (dis)information. I began this journey by exploring the flat Earth movement with my master's thesis and, among the various insights gained from the literature, I was particularly struck to discover that it was the Internet (via forums and blogs in the early 2000s) that breathed new life into this theory that had historically almost disappeared from public attention (Peterson, 2021).

I've in this way discovered how it is often some meandering of the Internet who acts as a rabbit hole for entering disinformation circles and adopting conspiracy theories, and while the flat Earth movement is mostly a "harmless" conspiracy, in recent years we have witnessed, for example, the rise of the QAnon movement that has developed on the extreme fringe of the U.S. political spectrum and led to the riots on Capitol Hill on Jan. 6, 2021. In addition, during the pandemic, many people believed conspiracy theories about the coronavirus, disinformation related to 5G technology that led to the growing polarization of vaccination, shaking public opinion in society with difficult to quantify but surely serious consequences from a public health perspective.

At the outset of my research, I examined the Flat Earth Movement before expanding my focus to broader topics, culminating in the publication of an article on the electoral debate surrounding nuclear energy—both civilian and military—in Italy. The reason for this change of focus is the desire to explore more relevant issues, where the dynamics of information and disinformation can play an important role in political decisions affecting society. The issue of nuclear energy and atomic conflict has gained prominence in recent years, particularly in the context of geopolitical instability and the shifting balance of power among major global actors. Given the potential for national election outcomes to generate far-reaching international consequences, it is essential to mitigate the influence of disinformation agents—including foreign governments, non-state actors, political figures, high-profile individuals, and media personalities—on the electoral debate.

In recent years, digital technologies have greatly enhanced the ability to process information, not only in terms of volume, but also in terms of complexity and speed of processing. The evolution of communication technologies marked a pivotal moment, ushering modern society into the Information Age (Shannon, 1948). Social media has been a disruptive communication technology that has shaped the evolution of social relations in modern society (Amelia & Balqis, 2023), making it essential to monitor developments and understand the nuances of the communication landscape to address phenomena such as disinformation (Wardle & Derakhshan, 2017) that may have a negative impact on public health, public security, civil discourse, political participation and equality (European Commission, 2022).

This doctoral research explores the social media ecosystem by investigating the intersection between the dynamics of disinformation and the nuclear energy debate, with a primary focus on the Italian debate at the national level by exploiting the 2022 general elections. Through this main publication the research explores how the actors involved shape and amplify narratives around nuclear energy on social media. This case study, highlighting key patterns in the politicisation and dissemination of narratives, formed the basis for a broader investigation. Building on these insights, the other two contributions explore, respectively, the local and regional controversies surrounding the National Radioactive Waste Repository in Italy and the international context, investigating the social media discourse on the nuclear implications of the conflict between Russia and Ukraine.

The research primarily investigates disinformation within the social media ecosystem. It is important to acknowledge, however, that the broader information environment extends well beyond social media platforms, and patterns of internet use vary significantly across national and regional contexts. As Arora (2019) highlights in her work on the Global South, digital engagement is deeply shaped by local infrastructures, cultural practices, and socioeconomic conditions. A second critical factor is the structure of national media systems, which differ across countries and influence their resilience to disinformation. For instance, some Western democracies exhibit stronger institutional safeguards and media literacy frameworks, making them comparatively less susceptible to large-scale disinformation (Humprecht, Esser & Van Aelst, 2020). Additionally, the design of electoral systems plays a crucial role: majoritarian systems may encourage targeted disinformation strategies, while proportional representation models could be more vulnerable to microtargeting (Kruschinski & Haller, 2017).

While this study is grounded in the interdisciplinary field of social media studies—drawing on communication studies, media studies, and computational social science—its primary focus is on the cross-platform dynamics of disinformation. It does not aim to offer a comprehensive comparative analysis of national media systems or electoral infrastructures. Instead, it leverages the flexibility of digital methods to conduct an exploratory analysis of the social media ecosystem, with the goal of uncovering its nuances and peculiar dynamics.

In the following sections, we will define the central concepts to this research, including the notion of the social media ecosystem, the concept of disinformation, and their connection to the debate on civilian and military nuclear issues. Additionally, we will outline the methodological approach employed in this study.

1. Social Media Ecosystem

The dream of the open web placed emphasis on broad and free opportunities for knowledge and sociability. Public access would no longer be mediated by gatekeepers such as publishers and broadcasters who had played such a powerful role in the previous century. The power to speak would be more widely and equally distributed, with more opportunities to respond, deliberate, criticize, mock, and contribute. Many hoped that this participatory culture would be more egalitarian, more global, more creative, and more inclusive. With the web, communities could be based not on kinship or commonplaces, but on shared interests, and they could set their own rules and priorities, with any kind of democratic consensus. The ultimate vision was to have an unmediated public sphere, a natural collection of crowd wisdom, and an unlimited cultural landscape (Gillespie, 2018).

As a matter of fact, reality is definitely more complicated.

The impact of new online media has radically altered the media environment, transforming the variety of content that users encounter and the process of exposure to that content (Cann, Weaver & Williams, 2021). The Media Ecology "[...] looks into the matter of how media of communication affect human perception, understanding, feeling, and value; and how our interaction with media facilitates or impedes our chances of survival. The word ecology implies the study of environments: their structure, content,

and impact on people. An environment is, after all, a complex message system which imposes on human beings certain ways of thinking, feeling, and behaving" (Neil Postman, 1974). McLuhan's (1962) "Global Village", an originally optimistic vision of universal connectedness, collides with the reality of platform power, data control, and radical indifference. The future of our digital society depends on our ability to navigate this web of interrelationships, ensuring that platforms serve the public interest and respect fundamental principles of privacy, sovereignty and justice. Media ecology offers a framework for grounding the distributed concerns of the current media landscape (e.g., disinformation, algorithmic discrimination, surveillance and predictive analytics, techno-capitalism, labor and movement activism) into something tractable, open to new perspectives of seeing and analyzing relationships within and between media ecosystems. (Nichols & LeBlanc, 2021).

These dynamics are particularly relevant in social media, since they are Internet-based platforms capable of creating channels of mass personal communication (Carr & Hayes, 2015), which means capable of reaching a large audience while maintaining a personal touch, thus closing the gap between mass and interpersonal communication. Social media platforms are often referred to as social networking sites (boyd & Ellison, 2007) and fall under the generic definition of computer-mediated communication (CMC). Josè van Dijck adds another complexity level describing how those "platforms" have a huge influence in the ways people communicate, work and socialize (van Dijck, Poell & De Waal, 2018). Her analysis highlights how technological platforms influence human behavior through algorithms and data retrieving mechanisms. Platforms such as Google, Facebook, Amazon etc. acts like primary interfaces through which individuals interact in the digital world, and they are not neutral instruments, since they shape people's perceptions, decisions and even personal relations. Those platforms not only connect people but also organizations, institutions and markets, redefining the boundaries between public and private (Boyd, 2010), consumption and production (Fuchs, 2011). As Van Dijck & Poell (2013) point out, the logic of social media has progressively spread to all spheres of public life and strongly conditions the rules of social interaction, resulting in recent neologisms born to describe the continuous interconnectedness, such as the term "onlife" (Floridi, 2015).

From an economic standpoint, discourses about protecting speech and community fail to take into account what ultimately matters most to platforms: keeping as many people on the site for as long as possible, interacting as much as possible (Gillespie, 2018). Over time, social media platforms have evolved into ecosystems that keep users in their services and make data collection more comprehensive and valuable. Platforms have developed new ways to keep users browsing and posting, to push them to reveal their preferences, and to save it all as personalized data so that it can be sold to advertisers and content partners. To accomplish this, social media platforms have evolved into services that host, organize and circulate content shared by users or social interactions for them, without having directly produced or commissioned that content. What they do is make available an infrastructure, beneath this circulation of information, aimed at processing data for customer service, advertising and profit. These dynamics have psychological effects that users and researchers are continuously trying to identify and define (Bayer, Triệu, & Ellison, 2020). After a period of positivity about new communication technologies such as social media, which were supposed to push toward a golden age of global democratization, many segments of society such as the media, researchers, civil society, and politicians are now concerned about how social media may eventually come to undermine democracy (Tucker et al., 2018).

1.1 Platformization and Implications for Digital Society

The term platformization refers to the expansion of digital platforms into various socio-economic domains. This process is characterized by the integration of platform logics—such as datafication, automation, and commodification—into existing institutional and media infrastructures (van Dijck, Poell, & De Waal, 2018). Scholars have shown how platforms have become the dominant infrastructural and economic model of the social web (Helmond, 2015). The field of platform studies explores how these systems both enable and constrain communication and expression through their technical and economic structures.

As platforms evolve, their services increasingly acquire infrastructural qualities, becoming essential to social and economic life. At the same time, both new and legacy infrastructures are being reorganized according to platform logic (Plantin et al., 2018). This reconfiguration highlights the political economy of platforms, which emphasizes the commercial imperatives and power asymmetries that shape platform governance, algorithmic curation, and user interaction. Digital platforms have emerged as a dominant business model operating within capitalist frameworks that prioritize engagement maximization and data extraction (Srnicek, 2017; Fuchs, 2017; Zuboff, 2019). Today, nearly every social need is mediated by opportunities to "connect" online. However, this convenience often comes at the cost of privacy, as vast amounts of personal data are collected and monetized—often without users' full awareness (Couldry & Mejias, 2019). Critically, datafication can reinforce existing social inequalities. Algorithmic systems, trained on biased or incomplete datasets, tend to reproduce patterns of discrimination—whether based on socio-economic status (Eubanks, 2018) or race (Noble, 2018).

In this context, content moderation remains under-examined by the public, despite its growing influence in shaping social norms, cultural expression, and democratic discourse (Gillespie, 2018). Understanding the spread of disinformation, therefore, requires attention to how platforms function as political-economic actors—balancing user growth, advertiser interests, and regulatory scrutiny, often while resisting meaningful transparency. Recent research has highlighted how algorithms embedded within platforms are not neutral tools but become integral to social practices. Users engage with these algorithms as powerful mediators of information, identity, and interaction (Bucher, 2018). Notably, platforms tend to amplify content with high engagement potential—regardless of its veracity—thus contributing to the spread of misinformation, polarizing narratives, and outrage-driven media (Huszár et al., 2022; Guess et al., 2019). Content moderation, therefore, has never been more critical. The very tools used by platforms to combat trolling, hate speech, or explicit content can also suppress essential forms of expression (Gillespie, 2018). Moreover, moderation is now performed at scale, often outsourced to low-paid labor forces employed by some of the world's largest tech companies (Roberts, 2019). This system reflects and perpetuates the broader capitalist logics embedded within platform governance.

1.2 The Core of the Ecosystem

Individuals are nowadays faced with a wide variety of media options (both traditional media and social media platforms), new mechanisms of exposure (user-selected or platform-driven), and considerable production of user-generated content (Valkenburg & Peter, 2013). Users are at the core of this ecosystem and create, share, and interact with content on different platforms. Research suggests that the set of social tools varies considerably depending on the specific user, and further work is needed to

examine individual differences in how users conceptualize social platforms (Bayer, Triệu, & Ellison, 2020). Recent studies have found that the use of multiple sites helps solve the problem of accessing different networks: participants in Lindley's study (Lindley et al., 2016) pointed out that different social media provide access to different social networks, and Vitak et al. (2014) determined that users switch communication channels voluntarily for the purpose of reaching different social groups. As a result, many social media platforms display their users' other social media accounts or employ permeability that allows them to share content and contacts (Zhao, Lampe, & Ellison, 2016). Within this ecosystem, each user selects a set of tools that they deem necessary to achieve their communicative goal, creating their own personalized media ecology. As pointed out by Zhao, Lampe, and Ellison (2016), many studies on social media focus on a single platform, bypassing the reality of the facts, which, on the contrary, show that most users employ different platforms within their communication practices for the purpose of accessing the different users and networks they intend to influence, which implies that the consequences of social media behaviors are best grasped when taking into account the personalization of the ecosystem implemented by users (Zhao, Lampe, & Ellison, 2016). The availability of different platforms in fact ensures more opportunities for users to negotiate their needs, and means that you are less likely to find anyone you want in a single "place."

The social media ecosystem is the complex and interrelated set of platforms, people, content and interactions that define the online social media environment. This ecosystem includes a variety of platforms, including popular social networks such as Facebook, Twitter, Instagram, and LinkedIn, as well as blogs, forums, video sharing platforms such as YouTube, and instant messaging apps such as WhatsApp and Telegram. Content can take many forms, including text, images, video, links and other media. Users can interact with others, create groups, share common interests, and engage in discussions on a variety of topics. These technological tools allow anyone to easily broadcast political information to large numbers of citizens, which can lead to a more pluralistic public debate, but they also risk giving space to extremist voices and actors who seek to manipulate the political agenda for personal financial or political gain (Tucker et al. 2018). An increasing body of research highlights the role of disinformation in this process, as false or misleading content disseminates rapidly through social networks, often exploiting algorithmic amplification and user engagement mechanisms (Vosoughi, Roy, & Aral, 2018). Disinformation campaigns not only disrupt public discourse, but can also deepen political polarisation, erode trust in democratic institutions, and diminish the public's ability to make informed decisions (Benkler, Faris, & Roberts, 2018).

Some of those platforms can have more reach and influence than many countries, and the decisions taken by these entities can have far-reaching consequences for people's real lives and geopolitical dynamics. Shoshanna Zuboff (2019) highlights an intrinsic risk in the growing dominance of digital platforms, coining the term "Radical Indifference" to refer to the massive use of personal data and indifference to the ethical and social implications of the online behavior this data comes from. Zuboff (2019) explains how, in a context of "new neoliberal rationality", the data that is left behind by users in online and off-line activities is the raw material that allows huge companies to transform them into behavioral data to use in order to improve products or services. Platforms collect huge amounts of personal data without transparency or clear consent, challenging the principles of privacy and individual control. This unscrupulous approach can lead to a loss of autonomy and rights, where individuals simply become objects of analysis and exploitation. The Big Tech companies (Google and Facebook above others) have the possibility, expertise and ability to monitor society in their online behavior. Radical Indifference refers to increased data availability on which they perform measurement of online behavior while remaining deliberately unresponsive to the meaning of that experience, avoiding as much as possible content moderation. This approach translates into considering positive and negative material equivalents, thus leaving room for the proliferation and circulation of poor quality content which fuels deleterious

phenomena for society such as disinformation (Zuboff, 2022).

As claimed by Ciofalo, Leonzi and Ugolini (2019), a comprehensive understanding of the social media ecosystem is essential, as its underlying technological and cultural logics play a pivotal role in shaping the dynamics of disinformation. Effectively addressing disinformation necessitates an in-depth analysis of the mechanisms and channels through which it proliferates, underscoring the importance of examining the broader social media landscape.

2. Disinformation

The spread of disinformation and polarized perspectives is a problem that scholars depict as supercharged by contemporary social media dynamics (Bounegru et al., 2018; Daniels, 2018; Rogers, 2021). Disinformation used to pollute the information ecosystem and push a preferred narrative can create misperceptions that could distort the opinions of individual citizens, and the effects of individual-level misperceptions can aggregate into collective public opinion distortions that can influence governance policies and electoral outcomes (Tucker et al., 2018). A number of scholars concord that the quality of democracy depends closely on the quality of information and informed citizen participation. Italian philosopher and jurist Norberto Bobbio (1984) stresses the importance of information in the democratic process; Robert Dahl (1989), one of the most important theorists of democracy in the 20th century, reiterates that an inclusive democracy requires a well-informed citizenry to function properly; and german sociologist Jurgen Habermas (1981), highlights the importance of a free public sphere where citizens can discuss and exchange information openly and transparently, emphasizing that public debate must be well-informed, critical and rational to ensure high quality democratic deliberation.

Born & Edgington (2017) describe the "information problem" as consisting of three related issues: Disinformation, Misinformation and Online propaganda. Disinformation and Misinformation can often be confused and are distinguished primarily by the intentionality of deception. On the one hand, Disinformation is false information disseminated intentionally to deceive its recipients (Shu et al, 2020), while Misinformation is false, incorrect, or misleading information (Fetzer, 2004) that can be propagated unintentionally, often regarded as an "honest mistake" (Shu et al., 2020). Users may contribute to propagation simply because of the trust placed in sources such as family members, friends, colleagues, or influencers in their social network. Therefore, the original intent would not be to deceive, but to inform their friends who are part of the social network. Online propaganda consists of information that is potentially factually correct but packaged in a way that denigrates opposing viewpoints (Tucker et al., 2018). The presence of the adjective "online" in relation to propaganda highlights the role of technology in contemporary informational dynamics, particularly social media and its ecosystem, which, by facilitating and amplifying the dissemination of content (Guess et al., 2023), has led to a radical evolution in the nature of information (Grover, Kar, & Dwivedi, 2022). In these cases, the purpose is not to present information as much as to garner public support (Born & Edgington, 2017). The political connotation of online propaganda is Hyper-Partisan news, which are news aimed to depict in a positive way a political party or its members and at the same time taunt or blame political opponents. A key goal of online

propaganda is precisely to ensure that some traditional media news stories are viewed more than others (Sanovich et al. 2018).

Other recurring terms in the literature are fake news, hoax, conspiracy theories, and rumors. Fake news is news articles from websites falsely claiming to be news organizations that "publish" deliberately false stories for the purpose of raising advertising revenue or fueling propaganda and going viral through the media and social media (Wu et al., 2019). Economists Hunt Allcott and Matthew Gentzkow (2017), who are experts on these phenomena, define fake news as "intentionally and verifiably false news articles that can mislead readers," sending "distorted and unrelated signals to reality" that create "private and social harm, making it harder [...] to understand how things are going." Although the definition in the literature is widely agreed upon, there are those who frame fake news as a form of disinformation (Shu et al, 2017) by emphasizing the intentionality (news created with dishonest intentions) and those who instead point to it potentially as misinformation (Wu et al, 2019) by pointing out that it could be unintentionally shared by unaware users. Many researchers also use the term "hoax" (from hocus, which means to trick), to refer to deliberate false information (Vedova et al., 2018). Hoaxes are messages intentionally created with the aim of being spread to a large number of people, to "persuade or manipulate other people to do or prevent pre-established actions, mostly by using a threat or deception" (Vukovic, Pripužic, & Belani, 2009). A conspiracy theory "involves the denial of official and commonly accepted explanations of the causes of an event" (van der Tempel and Alcock (2015), but it also tends to reduce the complexity of reality by explaining significant aspects of society and politics as plots orchestrated by powerful organizations and/or individuals (Bessi et al., 2015) to whom are attributed hidden, illegal, and malicious intent. Conspiracy theories are beliefs largely ignored by society (van der Tempel and Alcock, 2015), but the involvement they create in users should not be underestimated (Cinelli et al., 2022). Unverified information and rumors are pieces of information that can be either true or false. After verification, those verified to be false or inaccurate obviously belong to disinformation. It may trigger similar effects as other types of disinformation, such as fear, hatred and astonishment, and according to Rosnow, (1991), "rumors" are "infused with private hypotheses about how the world works." Other commonly encountered terminologies in literature are Urban Legends, Trolls and Spam. Urban Legend consists of intentionally spreading disinformation related to fictional stories about local events whose purpose can often be entertainment (Wu et al., 2019). Troll is a behavior which aims to cause unrest and arguments against a certain group of people. Unlike other types of disinformation that seek to convince recipients, trolling aims to increase tension between ideas and ultimately deepen hatred and widen the gap. For example, the likelihood that a median voter will vote for a certain candidate can be stimulated by trolling, making it a behavior that can be related to political polarization. Finally, spam refers to irrelevant information sent to a large number of users. The hoaxes defined above can be seen as a combination of trolling and spam.

For the purpose of simplicity in the rest of the chapter we will use "disinformation" as an umbrella term to include all the different nuances defined earlier, to refer to any type of information one could encounter online that could lead to a factually incorrect view of the world.

Disinformation on Social Media can exist in many forms (textual, images, video etc.), and furthermore there are several ways in which it can be generated, either by human agents, machine generated or a combination of the two (Shu et al., 2020). Image editing can completely change the meaning of images, and recent technical advances in the field of computer vision make it possible to model videos by replacing people's faces in an increasingly realistic way. This technology, which goes by the name Deepfake, has so far been used primarily for malicious purposes, such as using the faces of celebrities in pornographic videos (Lee, 2018) or editing politicians' speeches that have the power to shift public opinion and alter the course of democratic elections (George, 2019). Other aspects worthy of consideration that increase

the detection difficulties are inherent in the nature of the different types of disinformation. By definition, fake news is news that needs to be verified as untrue, implying that debunking can only be accomplished after it has been disseminated online. Some scholars also point out that satire can sometimes be difficult to distinguish from disinformation, as it is characterized by fake content that, while entertainment-oriented, may confuse some users (Rubin, Conroy, Chen, & Cornwell, 2016). On the other hand, with regard to online propaganda and hyper-partisan content, the terrain becomes slippery when one has to draw the line on what can be called true or false, as it fits into an important framework for democracy that is inherent in freedom of speech and the risk of incurring censorship.

2.1 Users as Neutrons: Triggering the Fission/Fragmentation of Narratives

Many scholars have explored how media ecology of disinformation has changed over time from print media and radio/television to online news and social media (Shu et al., 2017), where more political information is being shared than ever before, and ordinary citizens play an active role in the news ecosystem (Tucker et al., 2018). Content is often highly sensationalistic and written using extreme sentiments so as to affect the reader and make him or her interact more (Shu et al., 2017), increasing the chances that the content will become difficult to intercept due to the virality of social media (Vosoughi, Roy, & Aral, 2018). Looking at the users, the main aspects are the ease in creating alternative sources/accounts of information and the possibility of automation through the use of bots that fuel spreadability (Shao, Ciampaglia, Varol, Flammini, & Menczer, 2017). This change is partly due to the nature of social media platforms that make it quicker and less expensive to consume news compared with traditional news media, such as newspapers or television; and make it easier to share, comment and discuss the news with friends or other readers (Shu et al., 2017). Additionally, in the digital age we live, any user can generate and broadcast content that can potentially reach a global audience. The effort to produce sources of disinformation is increasingly less due to the ease of creating and publishing material online and the vast reach of social media platforms. This creates room for the emergence of "alternative media" (Starbird, 2017) that witness increasing popularity by sharing fake articles, opinions masquerading as facts, and even highly polarized conspiracy theories and pseudoscience (Shu et al., 2020). These alternative news sources are often politically oriented, they challenge the narratives of the mainstream media, and, in addition to targeting very specific audiences, they risk fueling a general distrust of legitimate information sources (Haller & Holt, 2019). Although many misperceptions are self-generated (Thorson, 2015), these distortions can be suggested, amplified and exploited by political elites, who often seek to fuel false or misleading claims to promote their own policies, win elections or avoid accountability for their performance in office. (e.g., Fritz et al. 2004; Flynn et al. 2017), or the public may also misunderstand the state of wars, especially early in a conflict (Baum & Groeling 2009).

The information environment nowadays is built in a way that makes it possible for any news to cross the platforms and the mediums: fake news sites are not the only sources of false information but the traditional media can also promulgate false hoods simply by reporting on them (Watts, Rothschild & Mobius, 2021). There are different ways to lead a person to reach an unsupported conclusion that do not require explicitly saying something false, for example presenting partial or biased data, a selective quote

of sources, omitting alternative explanations, equating arguments improperly, confusing correlation with causation, using loaded language, insinuating a claim without actually making it (e.g., by quoting someone else making it), strategically ordering the presentation of facts, and even simply changing the headline can all manipulate the reader's (or viewer's) impression without their awareness. These practices are pervasive in traditional professional journalism and are not restricted to political topics, although that is often the focus of research on media bias. Inaccurate and misleading coverage is potentially pervasive in other journalism areas, including fundamental domains for public opinion and democracy such as science, health, and business (Watts, Rothschild & Mobius, 2021). The result of this is that social media has a complex relationship with traditional media. On the one hand, social media has clearly become a tool for traditional media reporting, and at the same time, the majority of political content shared on social media is produced by traditional news media outlets.

In addressing this complexity, we encounter the concept of fragmentation, which several scholars have framed as a potential precursor to polarization (Schmidt, 2017; Sunstein, 2017). The fragmentation thesis refers to the idea that the exchange of information between users leads to ideological/political/social division and the formation of different homogeneous groups (Bright, 2018). Several empirical studies on social media (Quattrociocchi, Scala, & Sunstein, 2016; Yardi & Boyd, 2010) have shown that some degree of fragmentation exists. The interaction between individuals is triggered by an event whose outbreak causes rapid relevant information spread on the Internet. In the evolution of online public opinion, the outbreak of a social hot event usually gives rise to discussion from multiple perspectives, and individuals' participation in topics of different dimensions will form their attitudes towards the topic. Affected by information from different sources, users' comments describe various perspectives and vary over time, leading to fragmentation into subtopics. The interaction of viewpoints about different topics and subtopics makes public opinion escalate to a climax, resulting in public opinion polarization (Chen et al., 2021). For example Arlt, Rauchfleisch & Schafer (2019) conducted a social media analysis on Twitter, finding fragmentation among Switzerland users discussing the "Nuclear Withdrawal Initiative." They found an active exchange both within and, even more importantly, between the communities, which indicates a rather pluralistic and internally connected debate, findings clearly in contrast with those of prior studies concerning political debates on social media that identified echo chambers. As empirically proven by Bright (2018) this dynamic can also be self feeding by creating a loop in which polarization and fragmentation reinforce each other. The intersection of these notions gives rise to the concept of multi-polar polarization (Martin-Gutierrez, Losada & Benito, 2023) which highlights the fragmentation of society into multiple distinct and competing groups rather than a simple binary division.

Polarization has been an issue that worries scholars since the '60 of the XX century, and the new technological paradigm we are living in seems to add other variables to the concept. Since the term is sometimes used referring to a static property and sometimes to an ongoing process (DiMaggio et al., 1996), finding a common and shared definition of polarization is not an easy task. The Oxford dictionary defines social and/or political polarization as "the act of separating people into two groups with completely opposite opinions on a topic". A fundamental aspect in the above definition is the assumption on the existence of two opposing sides. The two sides typically correspond to either supporting or opposing a cause. Although this definition appears straightforward and unambiguous, polarization is a complex phenomenon having different declinations that over the years scholars have defined and analyzed, focusing on different aspects of political and social life. Polarization is usually described highlighting the negative consequences of polarization such as the possibility to lead to legislative gridlock (Binder, 2004; Morris, Abrams, & Pope, 2005) resulting from entrenched partisan divisions that hinder effective lawmaking and compromise. Another negative effect is the erosion of democratic norms which refers to the weakening of the foundational principles and practices that sustain a healthy democracy,

such as respect for the rule of law (Putnam, 2000), tolerance for opposing viewpoints (Mann & Ornstein, 2016), and the integrity of democratic institutions (Levitsky & Ziblatt, 2019). Some scholars have also pointed out some positive effects such as the possibility of fostering political engagement (Zaller, 1992), clarity in political choices (Wilson, 2021), and democratic vitality (Schattschneider, 1975).

There are several contributions in the literature that discuss the interplay of disinformation, polarization, and fragmentation. Benkler, Faris & Roberts (2018), in "Network Propaganda," discusses how the modern media ecosystem fosters a fragmented public sphere with multiple polarized groups through disinformation and propaganda. Walter Lippmann's foundational insights in "Public Opinion" (2017) provide a broader understanding of how public opinion can form and fragment in complex societies, applicable to the multi-polar polarization observed in the digital age. Andrew Chadwick's "The Hybrid Media System" (2017) elaborates on how interactions between old and new media create complex communication patterns, leading to a fragmented public sphere with numerous competing narratives. Additionally, Zeynep Tufekci, in "Twitter and Tear Gas," (2017) examines how social media platforms enable the formation of diverse activist groups, each with distinct agendas, further fragmenting the political environment. Chris Bail, in "Breaking the Social Media Prism,"(2022) emphasizes how social media generates multiple echo chambers, each reinforcing different identity bubbles and contributing to a multi-polar political landscape.

This research aims to explore the complex dynamics surrounding the civil and military nuclear debate, with a particular focus on how disinformation interacts with the fragmentation of the social media ecosystem. Given the articulated landscape, it is crucial to examine not only individual platforms but also the interactions and interdependencies between them. Disinformation's impact on the nuclear debate cannot be fully understood without considering the broader context of how information circulates across various platforms, the differing levels of user engagement, and the underlying socio-political and economic forces that shape online discourse.

To effectively capture these complexities, the research will employ a methodological approach tailored to examining the contemporary social media ecosystem—a dynamic and evolving network of platforms, each with distinct user bases, functionalities, and regulatory frameworks. By analyzing the interaction between disinformation and social media fragmentation, the study aims to offer insights into how digital information environments influence public attitudes toward nuclear policies and technologies.

3. Nuclear Energy, Atomic Conflict & their relation with Social Media and Disinformation dynamics

The nuclear industry has historically lacked steady and trusted communication to the public. Poor public communication acts as a catalyst for the breeding of misinformation and disinformation within the public sphere. This misinformation and disinformation is oftentimes used as scare tactics in movie and television plots, or used in politics to forward an agenda (Bachstein, 2016). Public reactions following nuclear events reinforce the need for effective communication in order to maintain the high level of transparency necessary for long-term local acceptance and support for nuclear facilities. An absence of

trustworthy communication leaves a vacuum that will quickly be filled by rumors and fake information (Thakur & Ward, 2019). Ho et al. (2022) examine how fake news and fact-checking influence risk perceptions toward nuclear energy, emphasizing the importance of reliable sources to counter disinformation. To build trustworthiness, R. B. Hayes (2022), has reviewed the technical topics of social and political debate surrounding nuclear energy with a focus on the unbiased and objective science of these issues including nuclear waste, accidents and overall risk. Other studies focused their attention on the ideological clash between potential benefits of nuclear energy such as reliable energy production, economic competitiveness and stable electricity prices, and the potential adverse effects of nuclear energy such as the possible proliferation of nuclear weapons (Ho & Kristiansen, 2019). Hoban and Rister (2024) explore the use of nuclear anxiety as a tool of war, focusing on the disinformation campaign around the Zaporizhzhia nuclear power plant and the role of the media in shaping public emotions.

The role of social media platforms in influencing the public debate on nuclear energy has pointed some attention from scholars, especially in the wake of nuclear incidents or major debates about energy policy. Li et al. (2016) examined the online discourse on Twitter following the Fukushima-Daiichi accident, highlighting how sentiment and risk perception evolve on social media platforms. Suzuki (2021) in Japan established that the biggest impact of the Fukushima accident has been the loss of public trust, with the policy debate divided between "pro" and "anti" nuclear power. The author argues that to regain public trust the Country needs to establish independent oversight organizations that actually lacks and impasse the debate. Kim and Kim (2014) studied the debate on social media using opinion mining techniques and demonstrated how these platforms serve as a space for opinion formation and dissemination. McBeth et al. (2022), in a recent work pointed the attention on the ideological aspect related to the nuclear energy debate, while Latré, Thijssen & Perko (2019) highlights as many studies largely ignore political factors, focusing instead on psychometric variables such as risk perception, benefit perception and trust. They conducted a survey in Belgium finding that parties have a net-effect and a polarizing impact on public opinion regarding nuclear energy although the effect is modest if compared with the psychometric variables. Cobos-Urbina (2021) investigated the potential of social media for high-risk industries, using nuclear energy in Spain as a case study, to understand the value of these platforms in relation to crisis communication and public engagement. Lin (2022) focused on the affective aspect to study the online opinion and sentiment of Taiwanese population in relation to the first nuclear referendum of the Country. Ersoy & Iseri (2021) examined the role of the traditional and online media in environmental debates over the Turkije nuclear program within the country's polarized media system.

Their findings revealed that the media system matters in public debates on energy, and illustrate the complexities of the dynamics involved in shaping public perception of nuclear risk and the key role of the media in countering its effects.

The relationship between the information ecosystem and atomic conflict narratives is (not considering the recent literature on the Russian-Ukrainian conflict) less explored in the literature compared to the more widely discussed issue of nuclear energy. However, a significant reference can be found in the book Three Tweets to Midnight: Effects of the Global Information Ecosystem on the Risk of Nuclear Conflict (Lin, Loehrke, & Trinkunas, 2020). The various contributions within this volume examine different facets of how the modern global information ecosystem can have a substantial impact on international conflicts. McDermott (2020) focuses on the role of cognitive biases in the acceptance of post-truth narratives and investigates the limitations of human psychology in addressing the complexities of nuclear strategies in the digital age. Slovic and Lin (2020) examine the psychological underpinnings of risk perception in the context of nuclear conflict. Kumleben and Woolley (2020) analyze how disinformation campaigns exacerbate hostilities and explore the role of social media in facilitating these narratives, which have the potential to escalate tensions. Starbird (2020) and Greenhill (2020) explore how

the manipulation of narratives within the NATO context and the spread of extra-factual information can undermine crisis management efforts, leading to inadvertent escalation. Bruusgaard and Kerr (2020) discuss the challenge of information overload, which further complicates navigation within these scenarios, while Lewis (2020) provides a historical perspective on how disinformation and false intelligence have previously shaped policies concerning nuclear weapons for military purposes. O'Loughlin (2020) underscores the influence of identity narratives in shaping public opinion, which can reinforce ideological divides. Finally, Trinkunas et al. (2020) propose strategies to mitigate risks, offering urgent policy recommendations to counter disinformation. Collectively, these studies reveal how, in the contemporary digital landscape, narratives surrounding nuclear conflict are shaped by the dynamics of social media, disinformation, and cognitive biases, all of which contribute to the intensification of global security risks.

To understand the evolution of the digital ecosystem, it would be valuable to apply a similar abstraction to the Chernobyl disaster as that employed in Three Tweets to Midnight (Lin, Loehrke & Trinkunas, 2020) for the Cuban Missile Crisis—reimagining the event as if it had occurred in the age of social media. In the book, President Kennedy is depicted as publicly addressing the crisis via Twitter, leaked satellite images circulate on Facebook, and the crisis rapidly becomes a matter of public discourse. Applying this approach to Chernobyl, one could envision images of the ionized-air glow appearing on Instagram, videos of rescue operations spreading across platforms, heads of state delivering live broadcasts on Facebook, advising the population to wear masks, stay indoors, and keep windows closed. On closer reflection, this exercise appears extraordinarily intuitive. Supermarkets might witness frantic scenes of people stockpiling essential goods, while conspiracy theories about the explosion's origins and misinformation regarding improvised radiation protection methods would quickly emerge from forums and fringe platforms.

Disinformation represents one of the most insidious challenges of our digital age, influencing public opinion and undermining trust in institutions. The dynamics by which it spreads through social media, exploiting engaging narratives and persuasive techniques, make it difficult to distinguish the true from the false, polluting public opinion and potentially acting as a catalyst for phenomena such as polarization (Garimella, 2018), which amplifies social and political divisions. These divisions are are particularly prominent when discussing sensitive topics such as nuclear energy and atomic conflict, which encompass the complexity of political dynamics, environmental sustainability, economy, and the challenges of democratic governance. The relationship between disinformation and both civil and military nuclear energy has always been complex, as the topic is inherently intricate and often evokes fear and uncertainty (Bachstein, 2016). Disinformation regarding nuclear energy has its roots in the Chernobyl disaster and the Fukushima-Daiichi accident (Thakur & Ward, 2019; Weart, 2012), and several contributions analyze the role of disinformation in the context of nuclear crises, highlighting how it influences public risk perception and policy responses.

Stillman (1982) offers a historical study of disinformation during the Three Mile Island accident, showing how the dissemination of incomplete information fueled public fear and distrust. An interesting point of view comes from Rothman & Lichter that in 1987 (right after the Chernobyl incident) apportion blame on journalists and media for misperceptions of the public. Fukushima was the first nuclear accident to occur in the world where citizens have access to 24/7 social media outlets. The social media sites were filled with information regarding nuclear energy that were based more on mass rumor and even paranoia than facts (Thakur & Ward, 2019). Many online news sources were flooded with anti-nuke narratives aimed at pushing a fear of radiation, such as inferring an increase in cancer rates among the public from this incident (Weart, 2012). Koerner (2013) in her work described how nuclear power, including generation facilities and waste repositories, are seemingly stigmatized in American culture. She considered

the impact of widely broadcasting nuclear accidents and how media coverage might alter public risk perceptions, identifying how media coverage of accidents at Chernobyl, Three-Mile Island, and Fukushima overwhelmed scientific claims of safety and security in nuclear energy production. Anti-nuclear narratives are often driven by ideological motivations that can spread inaccuracies about environmental impacts and radiation risks. At the same time, pro-nuclear narratives may downplay legitimate safety concerns and exaggerate the cost-benefit analysis of nuclear energy. In this context, disinformation can evolve and affect various aspects of the public debate, ranging from influencing energy policies (Thakur & Ward, 2019; Ho et al., 2022) to exacerbating tensions between nations during periods of geopolitical crisis (Hoban & Rister, 2024; Starbird, 2020; Greenhill, 2020).

The intricate landscape described above illustrates an environment in which disinformation actively shapes the news production process through various biases, using selection (what one chooses to cover or ignore), emphasis (how important a particular story is and for how long), slant (how the headlines are written, the tone of the article, the relative emphasis of different facts), and finally outright deception (fake news, propaganda, etc.) (Watts, Rothschild & Mobius, 2021).Given the complexities of the situation outlined above, it is crucial to emphasize the significant challenges inherent in identifying disinformation. Early detection is critical to minimize the number of people reached and limit the damage, which is why there has been a focus on news dissemination models that seek to understand news propagation (Jin, Dougherty, Saraf, Cao, & Ramakrishnan, 2013; Zafarani, Abbasi, & Liu, 2014). However, these models can only be adequately studied after a significant amount of disinformation spread has already occurred, and therefore, this approach of detecting fake news/disinformation is not the most viable, and other options are currently developing. Some methods of disinformation detection have sought to exploit users, for example by allowing them to flag content that they consider potentially disinformative (Tschiatschek, Singla, Gomez Rodriguez, Merchant, & Krause, 2018). If a post receives a sufficient number of flags it is subjected to fact-checking and eventually removed. Some researchers have instead sought to measure the activity of disinformation actors to characterize their behavior (Shu et al., 2019), or by exploiting the sentiment of news content as an evaluation variable (Pamungkas, Basile, and Patti, 2019). A recent branch of detection has shifted its focus to leveraging artificial intelligence and neural networks to identify disinformation on emergent events, with the idea of transferring disinformation features recognized in past events to models that can identify new disinformation on unseen events (Wang et al., 2018). Another field focuses its attention on the study of networks for the identification of disinformation propagation pathways (Liu and Wu, 2018), which is evolving with the use of neural networks that are capable of identifying the representation of latent nodes in a graph (Bian et al., 2020). There are a number of initiatives aimed at mitigating disinformation with computational approaches that aim to identify the sources of such content (Barbier, Feng, Gundecha & Liu, 2013).

4. Methodology

4.1 Contextualizing the Digital Landscape

The prevailing narrative is that online disinformation is amplified in partisan communities of like minded individuals called Echo Chambers, defined as "a bounded media space that has the potential to both magnify the messages delivered within it and insulate them from rebuttal." (Jamieson and Capella, 2008). In these enclosed spaces disinformation goes unchallenged due to ranking algorithms that filter out any dissenting voice (see e.g., Pariser 2011; Del Vicario et al. 2016). One of the leading proponents of this

view is Cass R. Sunstein, who in his book #-Republic, warns that balkanized online speech markets represent new threats to democracy because they are a breeding ground for informational cascades of "fake news" and conspiracy theories (Sunstein, 2017). Other scholars pointed their attention to algorithmic bias produced by the increasing use of personalization in the ranking of search engine results and social media, that shape users' choices and lead to phenomena called Filter Bubbles (Eli Pariser, 2011). The Filter Bubble is an echo chamber produced primarily by the algorithmic filtering encountered in a platform in which results are filtered according to the user's preferences, that results in passive personalization of content without the user having any choice (Ross Arguedas et al., 2022). This has provided new fuel to the debate on the internet and social media as ideological echo chambers, characterized by people which during online debates selectively avoid opposing arguments, facing little resistance, presumably reinforcing and polarizing political views. The outcome of this process would be a society that is ill-informed and increasingly segregated and polarized along partisan lines, making political compromise increasingly unlikely.

To understand the echo chamber dynamics, media scholars looked at the interplay between media supply, media distribution, and media demand (Webster 2014). With a diverse media system and a multitude of independent voices expressed online, information supply has grown enormously in recent years thanks to the growth of the internet but it's improbable that the lone supply could lead to echo chambers, leaving distribution and demand as the main possible causes for the formation of them.

In terms of distribution, algorithmic selection by digital platforms such as search engines and social media that make personalized display decisions for countless users using automated systems might, some fear, generate filter bubbles by reducing the diversity of information people come across, serving them more attitude-consistent news and resulting in less cross-cutting exposure. But empirical studies, whether based on survey data or passive tracking data, have generally found the opposite. They demonstrate that reliance on secondary gatekeepers such as search engines and social media is in most cases associated with more diverse news use, due to automated serendipity and incidental exposure. This is a coherent finding in a rising number of survey-based studies (DuBois and Blank 2018; Fletcher and Nielsen 2018a; Fletcher and Nielsen 2018b; Beam et al. 2018) and studies based on different types of passive tracking data (Flaxman et al. 2016; Cardenal et al. 2019; Fletcher et al. 2021; Wojcieszak et al. 2021).

Finally, regarding media demand, the primary causal mechanism possible here is self-selection: some people actively opt into echo chambers as they prefer on the one hand news that aligns and reinforces their preexisting views (selective exposure to attitude-consistent information), and on the other hand they actively try to avoid counter-attitudinal information (selective avoidance of cross-attitude exposure). Different studies have found that algorithmic selection generally leads to slightly more diverse news use, the opposite of what the filter bubble hypothesis posits, but that self-selection, primarily among a small minority of highly partisan individuals, can lead people to opt into echo chambers, even as the vast majority do not, and document that limited news use remains far more prevalent than echo chambers are (Bakshy et al. 2015; Kaiser and Rauchfleisch 2020; Vaccari et al. 2016).

Even if most people aren't living in online echo chambers, they're nonetheless subject to the political influence of those who do. Sometimes confirmation bias, motivated reasoning, and social reinforcement from the communities we spent the majority of our offline lives with can result in holding exceptionally strong views, even though we are exposed to a wide range of different kinds of information via news and media (Ross Arguedas et al., , 2022). Empirical studies document that echo chambers are far more bigger in offline environments rather than online (Guess et al., 2018), and a growing amount of research rejects the filter bubble hypothesis (Bruns, 2019a; 2019b).

Nowadays the Internet allows individuals to discuss with people who have different ideas while also belonging to an online ecosystem that supports their values and opinions (Zerback and Fawzi, 2016). A phenomenon called Trench Warfare Dynamics (Karlsen, Steen-Johnsen, Wollebæk, Enjolras, 2017) builds on the observation that both confirming and contradicting arguments have similar effects on attitude reinforcement during online debates. The trench warfare does not refuse echo chambers, but describes a situation where attitudes are reinforced through both confirmation and disconfirmation biases, highlighting that positions can be reinforced through contradiction between individuals who hold different basic values and opinions. Elaborating on this, the trench warfare metaphor perfectly describes an environment in which two different behaviors occurs: hiding in the trench, which means configuring an echo chamber where you only discuss with fellow soldiers by potentially fueling confirmation biases, or "leaning beyond the trench to engage with enemies", which means interacting with users that hold different positions and potentially fuel disconfirmation biases.

The research design was influenced by the ongoing debate surrounding echo chambers and filter bubbles. On one hand, some studies highlight their existence, while others question their scope or even their actual existence. The phenomenon of echo chambers in the nuclear energy debate has been the subject of relatively few studies, which have yielded divergent findings. A study by Geiss, Sakketou, and Flek (2022) analyzing discussions on Reddit found no evidence of communities with opposing positions on the topic. Instead, it revealed a relatively homogeneous debate, with the majority of users expressing support for nuclear energy. This suggests the presence of an echo chamber characterized by a convergence of opinions. Conversely, the research conducted by Arlt, Rauchfleisch, and Schäfer (2018) on the Swiss referendum for nuclear phase-out presents a more complex debate on Twitter. The authors identified seven distinct user communities that, despite their differing positions, displayed high levels of cross-group interaction. This case demonstrates that while social media can contribute to the fragmentation of public discourse, they can also facilitate exchanges between opposing viewpoints. Consequently, the structure of online debates appears to be influenced by multiple factors, including the platform itself, the actors involved, and the specific context. In response to this theoretical uncertainty, a multiplatform approach was adopted, centered around the concept of serendipity (Walpole, 1754). The aim was to explore information dynamics beyond the boundaries of individual platforms, to understand the extent to which content traverses different platforms and how individuals may be exposed to differing viewpoints. By avoiding preconceived assumptions about the closure or openness of informational spaces, this approach allows for the observation of interactions between various parts of the digital ecosystem, revealing the underlying logic and the emergence of new perspectives, thereby providing a more complex understanding of the circulation of online content.

With the aim of exploring the widest possible range of digital environments, this study adopts an approach based on the concept of "Bridges," referring to hyperlinks that connect different social media platforms. Bridge is a notion taken from transmedia theory (Hayes, 2006), where the word is used to describe a narrative element/device or strategy that connects different parts of a story that spans multiple platforms or media. The Bridge concept is significant to the analysis to represent the hyperlink or cross-platform connections that enable information to move fluidly from one platform to another, highlighting how this object can be exploited by users as a communicative device to shift other users attention towards a secondary social media platform. For instance, a piece of content on Facebook might be shared through a link on Twitter, which then reaches a different audience. This inter-platform sharing expands the reach of information and increases its potential to influence diverse social media spaces. This destination platform, due to its different affordances, could constitute a completely different environment, potentially more favorable to push a preferred narrative on topics of public interest. Importantly, these bridges can serve both legitimate information and false content (misinformation/disinformation), configuring them as a "weapon" in the Trench Warfare Dynamic, and becoming critical to understand the diffusion of

content across the broader digital landscape. The fact that social media assumes high values as a destination for links means that the tendency to consume information through these platforms is consolidating (Newman et al., 2019). In particular, Weaver et al. (2019) illustrate that network analysis of such propagation models can reveal significant social structures of news engagement and consumption around political events.

Today we live in a hybrid media system where old and new media combine to reshape the patterns and dynamics of the media and their role in society (Chadwick, 2017), and where Social media are privileged intermediaries between media and users. Despite the fact that they do not directly produce information, they are becoming a place of transit towards information for many citizens. This evidences the progressive platformization of society (Van Dijck et al., 2018) and reinforces their position in the media system. Modern media ecology has inevitably undergone integration with digital studies (Lupton, 2015; Hayles, 2012; McPherson 2009), adapting research methodologies to explore how the Internet, social media and mobile technology fit into the broader media ecological model. What has been outlined so far has oriented this research toward an adaptive methodology, capable of fitting into varied contexts while maintaining enough flexibility to deal with different dynamics. This implies the adoption of multidisciplinary approaches and the capability to span different environments and application contexts.

4.2 Digital Methods

Digital Methods (Rogers, 2019) are research strategies that focus on the analysis of natively digital data available on web platforms, with the aim to re-proposing information in order to represent collective phenomena, social changes and cultural expressions. Digital methods takes the digital environment as both the source and context of inquiry (Rogers, 2013), and the fundamental concept on which Digital Methods analysis is based is the concept of natively digital object (NDO). By NDO we mean the entities that shape the Social Media platform and attribute their peculiarities to it. Those entities can be both objects identifiable in every platform, such as users, links and comments, but also a peculiarity of a specific platform: with reference to Twitter, for example, we will mean hashtags, retweets and mentions as entities, while with respect to Facebook we will mean like, reactions, pages. These digital objects should not be seen as something void but conceal a very specific meaning within them. The likes and reactions can be read as indicators of feelings, the retweet can be used as a yardstick for evaluating a content, the hyperlink count gives an estimate of the reputation enjoyed by that particular content, and the hashtag should not be considered only as a simple label but can in some cases represent a real message.

As Marres (2017) argues, digital methods have marked a methodological and theoretical turning point in digital sociology, enabling the development of an interdisciplinary dialogue situated at the intersection of:

- Computing, which provides analytical tools such as machine learning, text mining, and social network analysis;
- Digital media, which offers environments, objects, and practices for observation (e.g., hashtags, comments, algorithmic feeds, participatory cultures);
- Social life, which contributes everyday digitalized practices, including interactions,

identities, activism, and attention economies.

The epistemological mantra of digital methods is "follow the medium," that is, embrace the logic of the Internet to collect, systematize and analyze digital data, through tags, mentions, links or hashtags (Caliandro, 2016). Digital methods are inspired by actor-network theory (Latour, 1987; Callon, 1999), a sociological theory that investigates the complex relationship and interaction between humans and material objects in the construction of social reality. According to this theory, social formations consist of heterogeneous networks (Law, 1992) composed of both human and non-human actors such as institutions and objects (Thomas, Price, Shcau, 2013). The theory urges researchers to consider social formations as resulting from the activity of actors, and in this regard Latour (1987) coined the motto "follow the natives." Following the natives also means considering non-human actors (digital devices and platforms for example) as endowed with agency and therefore actors who collaborate in the construction of social formations (Latour, 2007). According to Venturini and Latour (2010), these so-called "quali-quantitative methods" are not merely a combination of statistical analysis and ethnographic observation. Rather, they represent a research methodology that is rethought from the ground up: from the identification of digital-native datasets (such as websites, archives, online media, and networks), through data extraction using digital techniques and tools (e.g., crawlers, scrapers, querying), to the structuring and analysis of data on digital—and preferably open-source—platforms.

The combination of "follow the medium" and "follow the natives" principles brings together two strategies that on the one hand observe communication mediated by the affordances of social media, and on the other hand observe the practices of use enacted by users, in a context in which users (human actors) and platforms (non-human actors) become co-authors of social research. Within a dynamic and fluid context such as social media, the task of the researcher moving in these environments is following the circulation of an empirical object within one or more online environments and observing the specific social formations that emerge around it in relation to the interactions of platforms and users (Caliandro & Gandini, 2019).

The imperative "follow" therefore urges us to find a way to move through the digital space and follow the research objects. At this point we can emphasize how movement within a digital space (from one site to another site) occurs through avenues named hyperlinks, which represent a basic component of the web's architecture (Ryfe et al., 2016) and its fundamental constituent elements, as if hyperlinks did not exist, we would not be able to understand the Internet as we currently do (Karlsson & Sjøvaag, 2018). This native object constitutes a peculiarity of the Internet and social media platforms and one of the most common ways to convey information. Sharing a link is an indicator of media engagement and aggregated link-sharing forms a network structure which maps collective media engagement (Cann, Weaver, & Williams, 2021). In social media, hyperlinks open new routes for the circulation of information and generate virality. Moreover, they are communication tools that serve as online curators (Sams & Park, 2014). Hyperlinks have a relational component (Fu, 2018; Sjøvaag et al., 2019). Using them, a user attempts to establish an association with another actor, as a news media, and communicates such affiliation to the general public (Shumate & Contractor, 2014). Including a link in a message spread by a social media platform implies a choice. The use of this resource is an intentional act (Ryfe et al., 2016). Link choices have a key strategic importance for three reasons. Firstly, they condition information flow, optimizing or blocking the diffusion of news (Ackland et al., 2010). Secondly, they are crucial to determine the relationships between users and media because they create links between them and connect them. This creates hyperlink networks (Fu & Shumate, 2017) and an interconnected media environment (Singer, 2019). Finally, they have an effect on how users find, consume and share news (Martin & Dwyer, 2019), or, in other words, what sources of information they prefer which could condition their perceptions and opinions. The hyperlink is the digital native object that allows us to operationalize in a practical way the

concept of Bridge between platforms.

Such a methodology, which is not rigid but adaptable to context, can address emerging perspectives and modify as needed. The goal is to be able to analyze phenomena from multiple angles, considering variables and external factors that often escape a more traditional approach. A significant contribution of digital methods is their capacity to render observable both micro-interactions and macro-structures, which emerge from the same assemblage of interactions, and a key advantage is that such methods are flexible enough to follow certain social phenomena branching off in different directions (Venturini & Latour, 2010). Moreover, such methodological elasticity allows one to operate in complex and evolving environments, where conditions change rapidly and require continuous rethinking of tools and solutions. This approach offers greater responsiveness, and also stimulates creativity in research, paving the way for findings that might not emerge in more rigidly structured settings.

The analysis is grounded in Digital Methods (Rogers, 2013) and relies on different computational approaches including Social Network Analysis (SNA) (Crossley, 2010), Natural Language Processing (NLP) and Machine Learning (ML) (Goyal, Gupta, & Kumar, 2018). Among these, the primary methodological approach employed in this study was social network analysis, which enabled the mapping of network nodes—representing users and/or platforms—to enhance understanding of the social media ecosystem and user interactions. Social Network Analysis (SNA) enabled an approach that sought to "follow the medium," allowing for the tracing of connections and interactions within the digital ecosystem. Additionally, natural language processing was utilized to label these networks and identify key characteristics. However, given the complexity of debates surrounding nuclear energy and atomic conflict (topics deeply embedded in polarized perspectives and subject to strategic disinformation) quantitative methods alone were insufficient. To fully grasp the intricacies of these narratives, qualitative content analysis was essential, allowing for an in-depth examination of discourse formation, nuances of different narratives, and the ways in which different actors shape and amplify particular viewpoints across digital platforms.

Digital technologies allowed in recent years a huge increase in the capacity to process information, not only its volume, but also complexity and speed of processing, increasing as a consequence the speed of communication. Social media are platforms that have become central parts of social and political life because they represent a source of information for people and thus acquire the potential to shape or change people's perspectives.

Research in this field presents several ethical challenges, particularly concerning privacy, methodological limitations, and the need for neutrality in highly polarized debates.

First, social media research must carefully consider the privacy of the individuals involved, especially when analyzing political discourse and disinformation narratives. To address this concern, user data has been anonymized unless the individuals are public figures. Additionally, where possible, data has been presented in an aggregated format to further protect individual identities.

The use of automated methods such as Social Network Analysis (SNA) and Natural Language Processing (NLP) is highly effective for large-scale data analysis. However, these techniques may overlook the nuances of discourse or lead to misinterpretations. To mitigate this risk, a human-in-the-loop approach has been adopted, integrating quantitative analysis with manual content analysis. This ensures that automated interpretations are verified and contextualized within broader discourse dynamics.

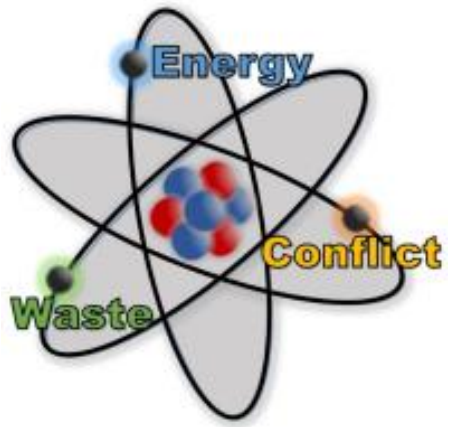
Another critical aspect is the inherently polarized nature of discussions surrounding nuclear energy

and atomic conflict, which are shaped by political ideologies, historical biases, and national security concerns. Maintaining neutrality is essential for the credibility of the research. To achieve this, researchers must engage in continuous self-reflection regarding their own biases and carefully select methods and sources that ensure the highest possible level of objectivity. To further enhance neutrality and reduce bias, the dataset has been diversified by collecting data from multiple platforms and combining quantitative and qualitative approaches. This methodological triangulation allows for cross-validation of findings, ensuring a more comprehensive and balanced analysis.

The methodology follows the principles defined so far, however each article has its own peculiarities in order to fit the specific research context of each of the contributions, which are introduced in the next chapter.

5. Introduction to the Articles

This study investigates nuclear energy as a paradigmatic example of dual-use technology. While it fulfills civilian functions such as electricity generation and radioactive waste management, it is also inextricably linked to military applications, including the development of nuclear weapons and strategic deterrence. These dual dimensions give rise to a broad spectrum of critical issues for contemporary society, encompassing political dynamics, environmental sustainability, economic ramifications, and the challenges of democratic governance.



1 Lithium-7 core showing debate elements as electrons

Given the complexity of the subject matter, nuclear energy has historically been a highly contested and polarizing issue, significantly influenced by public perception and often susceptible to disinformation.

This research is structured around three distinct contributions, each leveraging debates sparked by political and geopolitical events of varying scales. The primary contribution, which has already been published in a peer-reviewed journal, focuses on the Italian political discourse during the 2022 general elections. It examines both the energy-related aspects of nuclear power and the narratives surrounding nuclear conflict. Through this publication, the study investigates how different actors shape and amplify nuclear energy narratives within the digital ecosystem of social media. Building on this case study, the research has expanded to a broader investigation, currently comprising two additional contributions under submission. The first explores local and regional controversies surrounding the National Repository for radioactive waste in Italy, while the second examines the international discourse on social media concerning the nuclear implications of the Russia-Ukraine conflict.

The following sections will provide an overview for each of the articles.

5.1 Affective, defective, and infective narratives on Social Media about Nuclear energy and atomic conflict during the 2022 Italian electoral campaign

The main article, published in the journal "Humanities and Social Sciences Communications", is titled "Affective, defective, and infective narratives on Social Media about Nuclear energy and atomic conflict during the 2022 Italian electoral campaign". The paper explores the Italian electoral debate during the three months leading up to Italy's 2022 general election held at the end of September. The topic has primarily a national dimension and explored both dimensions related to the nuclear energy debate for civilian purposes and the atomic conflict narrative. In addition to the aftermath of the debate over the national radioactive waste depository, reigniting and fueling the Italian debate on civil nuclear power was the introduction of Nuclear Power in the EU Taxonomy for Sustainable Activities (European Commission, 2020). The EU Taxonomy for Sustainable Activities (i.e. the 'Green Taxonomy') is a classification system established to clarify which investments are environmentally sustainable, in the context of the European Green Deal (Fetting, 2020; Raux and Fischer, 2021). In essence, the EU Taxonomy is a system that determines environmentally sustainable activities and provides ways in which a company can calculate its sustainable turnover. The EU Taxonomy Regulation (Regulation No. 2020/852 of 18 June 2020) was officially published by the EU on 22 June 2020, after approval by the European Parliament on 18 June 2020, and entered into force on 12 July 2020 (List & Schiappacasse, 2020). The procedure raised a heated debate among member countries, within the European Parliament (Pistner & Englert, 2021; Conea, 2022) and also in the public opinion between those who support Nuclear Energy and those who oppose-it, denouncing it as an attempt of "Greenwashing". The general election also saw the discourse on nuclear energy debated inherently in the international geopolitical framework. In fact, with the start of the conflict in Ukraine the energy debate spread into a larger geopolitical perspective where the discourse expands to the military declination of nuclear technology. On the one hand, nuclear power is described as fundamental to mitigate the impact of Russian gas embargoes, especially in countries with higher import from Russia such as Italy and Germany (Halser, & Paraschiv, 2022). On the other hand, the presence of a narrative about the escalation of the conflict to an atomic conflict fuels a climate of fear that shapes the perception of nuclear power, whose implications on the geopolitical situation has been debated since the beginning of the conflict (Green, 2022).

This article aims to highlight the complexity of the contemporary social media landscape in relation to the spread of disinformation. It examines how mainstream platforms intersect with more marginal or under-the-radar ones, and emphasizes the significant role played by video sharing platforms and messaging apps. The research adopts a serendipitous approach, exemplified by the analytical strategy that begins from a selection of mainstream platforms and, rather than focusing on an in-depth analysis, it broadens the research using Bridge to other digital spaces to highlight cross-sharing and narrative dynamics. The contribution employs on the one hand, digital methods to map the discourse across different platforms, on the other hand, a qualitative content analysis which aims to capture the nuances of the discourse, characterizing the actors involved and the narratives they promote. The discussion builds on existing literature about the affective/emotional aspects of communication in social media ecosystems (KhosraviNik, 2018; Sakki & Martikainen, 2021; Laaksonen et al., 2022), underlining different rhetorical approaches used to push a desired narrative. Moreover, the focus on defective content underscores a dichotomy within the social media ecosystem between mainstream and fringe platforms (Rogers, 2021) where content analysis revealed spaces where disinformation is prevalent (Telegram, Rumble, Bitchute, and Sfero) which showcase a proliferation of alternative information sources. This charachteristics increase the potential of content to spread and became "infective", polluting the information ecosystem, and directing the attention toward the implications of this platform dichotomy in light of recent European

Commission legislative initiatives such as the Digital Services Act (DSA)(European Commission, 2022).

5.2 Mapping the Digital Public Sphere: Spatial Dynamics in the Debate on Italy's Radioactive Waste Depository

The second contribution, titled "Mapping the Digital Public Sphere: Spatial Dynamics in the Debate on Italy's Radioactive Waste Depository" explores local and regional controversies related to the radioactive waste subtopic which is closely related to civilian nuclear energy. More specifically the article concerns the public debate that has developed in Italy around the publication of the project documents to build a National Radioactive Waste Depository. The National Radioactive Waste Depository[1] will be a surface environmental infrastructure that will allow for the permanent safe storage of radioactive waste, now stored within dozens of temporary repositories across the country, produced by the operation and decommissioning of nuclear facilities and the daily activities of nuclear medicine, industry and research. The choice of site for the national repository is a complex and delicate process that involves several stages of technical, environmental and social assessment. Sogin, the company in charge of decommissioning Italy's nuclear plants and waste management, developed a Carta Nazionale delle Aree Potenzialmente Idonee (CNAPI, which means National Map of Potentially Suitable Areas), which identified several areas throughout Italy as possible sites for the depository, with 67 locations across 13 Provinces. The site selection process was accompanied by extensive public consultation designed to involve local communities and other stakeholders in decisions about the depository. The news regarding the National Radioactive Waste Depository instantly mobilized public opinion, politics, NGO, nimby committees and common people in Italy, which is one of the European countries most affected by the NIMBY phenomenon (Tipaldo, 2015). The site selection has generated considerable controversy and opposition from local communities concerned about the possible environmental and health risks associated with the waste repository. Fear of accidents, perceived devaluation of land, and impact on local economic activities, such as agriculture and tourism, are among the main concerns raised.

The topic, likely to be highly polarizing, made it possible to analyze the different nuances of disinformation, misinformation and online propaganda (Born & Edgington, 2017). Being the issue mostly developed in regional and/or local contexts, it has been addressed through an Issue spatiality framework (Stoltenberg, 2021), making it possible to analyse the intersection between real and digital space using Natural Language Processing and Machine Learning techniques. The aim is to explore the fragmentation of the debate through the spatiality of users, their network spatiality, and the spatiality of issues that will help to depict how space and place are embedded in public spheres in at least three ways: actors are emplaced in locations, their interactions form connections between these places, and the content of their communication locates issues (Pfetsch et al., 2021). The research demonstrated that both private citizens and local institutions found common ground in opposing the storage facility, using the term NIMYR (Not In My Region) to express this stance. The study aims to reflect on the fragmentation of social and digital discourse, which translates into real-world implications for politics, sustainability, and the economy. It highlights the importance of political communication in preventing polarization, which can lead to decision-making deadlocks in strategic public projects crucial for the development of a region or a country.

[1] The European Union (Article 4 of Directive 2011/70) requires that final disposal of radioactive waste take place in the membe r state where it was generated. Most European countries have or are in the process of establishing repositories to secure their very low and low-level waste. In order to permanently settle medium- and high-level waste, some European countries, including Italy, have the possibility to study the location of a common deep (geological) repository in Europe in order to enjoy the potential benefits of an optimized solution in terms of waste quantity, cost and time, as envisaged by EURATOM Directive 2011/70.

5.3 Navigating the Digital Battlefield: Social Media, Disinformation, and Atomic Narratives in the Ukraine Conflict

Finally, the third article titled "Navigating the Digital Battlefield: Social Media, Disinformation, and Atomic Narratives in the Ukraine Conflict" considers the international context by investigating the social media debate regarding the disparate nuclear implications of the Russia-Ukraine conflict, looking at both the energetic (concerning power plants) and military (escalation of the conflict) implications. Since the start of the invasion the term nuclear has been associated with the war chronicles in different ways. Beyond international embargo policies, the military operations fueled the debate since the beginning, for example in relation to the battles between Ukrainian and Russian armies for the control of two Nuclear implants: Chernobyl (sadly famous for the incident that happened on 26 April 1986), and Zaporizhzhya, the largest nuclear power plant in European territory. Additionally, the terms nuclear and atomic have been used to describe the worst case scenario regarding the conflict that suggests an escalation until the atomic conflict. From a geopolitical and military perspective there are multiple views regarding the possibility of atomic conflict among political actors (Barel, 2022; Sethi, 2022) and the broader public (Riad, Drobov, Alkasaby, Peřina, & Koscik, 2023). On the one hand, some experts argue that the nuclear weapons possessed by both sides act as a deterrent, while on the other hand, some advocate the possibility of using tactical nuclear weapons of "limited" destructive power. A peculiarity of the conflict was that it was immediately characterized by digital communication aspects. Information that in WW2 was filtered through war bulletins days away, nowadays thanks to ICT arrives in near-real-time, directly from the front, without any kind of filter. This aspect is interesting and must make us reflect on important aspects of information, such as reliability and propaganda, correctness and verification of the information conveyed.

The aim of this contribution is to build from the insights of the first article and explore on a larger scale the debate on nuclear energy and atomic conflict, looking at the complex relationships between disinformation, polarization, and fragmentation on the social media ecosystem. The quanti-qualitative methodology follows the same serendipitous approach, combining social network analysis and natural language processing to track the main narratives across platforms. A qualitative content analysis on data samples from each platform reveal that, within the social media ecosystem certain below-the-radar platforms are more prone to hosting borderline content. The nuances of the debate suggest that platforms can be strategically exploited by users to easily disseminate disinformation content with common cross-platform dynamics, avoiding monitoring from mainstream platforms. In addition, this contribution picks up the suggestion of the main article of this doctoral research (Persico, 2024) by trying to frame the consequences of disinformation dynamics and fragmentation of the social media ecosystem in the context of recent legislation such as the Digital Services Act (DSA) (European Commission, 2022), seeking to highlight potential weaknesses in the ability of existing legislation to adapt to the difficulties posed by the rapidly changing capabilities of the digital environment.

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ARTICLE

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Affective, defective, and infective narratives on social media about nuclear energy and atomic conflict during the 2022 Italian electoral campaign

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In the digital age, poor public communication catalyzes the spread of disinformation within public opinion. Anyone can produce political content that can reach a global audience, and social media has become a vital tool for political leaders to convey messages to the electorate. The 2022 Italian election campaign has seen the term "nuclear" debated with two different declinations: on the one hand, regarding nuclear energy for civilian use, and on the other hand, regarding the fear of an escalation of the conflict in Ukraine and the use of atomic weapons. This research aims to analyze the social media debate by exploring multiplatform dynamics to qualitatively identify and analyze the connections between social media platforms that we have termed Bridges, a concept drawn from Transmedia Theory to describe the narrative relationship between platforms. The methodological approach will follow an explanatory sequential design that will rely on digital methods to identify connections between platforms (bridges) and then apply an exploratory qualitative approach to enrich the data and capture the nuances of the debate. As expected, we found polarized positions and fragmentation on both issues of civilian nuclear energy and the atomic conflict narrative. Primary evidence shows bridges spreading affective, defective, and infective content across platforms in a multifaceted social media ecosystem. Affective refers to rhetoric that appeals to people's feelings. Defective means the discussion that brings attention to hyper-partisan news channels, fake news, and misinformation. Infective means bridges with below-the-radar platforms, niche channels, or pseudo-information channels. They use bridges with mainstream platforms to gain the potential to go viral. The paper highlights the importance of cross-platform and interdisciplinary approaches to addressing disinformation in a media ecosystem where social media plays an increasing role in a country's democratic dynamics.

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Introduction

Disinformation and conspiracy theories have always been used as tools of deception, and even more so in the Digital Age, poor public communication catalyzes the spread of disinformation in public opinion. Social Media have been the digital disruption of the 21st century, and its uninterrupted development continues to shape the media and communication landscape.

Nowadays, anyone can produce political content that can reach a global audience, with everyday citizens playing a crucial role in the information ecosystem (Tucker et al. 2018). Another pivotal aspect of modern information campaigns is that social media have become a fundamental instrument for political leaders to vehiculate messages to the electorate (Stier et al. 2018; Martella and Bracciale, 2022). In recent years, the term "fake news" became mainstream referring to falsified stories circulated on social media platforms to fuel propaganda or gain from advertising by becoming viral (Wu et al. 2019). The rise of political polarization and hyper-partisan media created a fertile ground for spreading disinformation, which poses an inevitable threat to society by influencing citizens' opinions and shaping the democratic processes.

On the 25th of September 2022, 63.91%[1] of Italians voted to elect the new Parliament, with high abstentionism that has characterized these general elections, which saw the competition of four main coalitions or movements.[2]The elections have also been characterized by a short period of the electoral campaign, being officialized by Republic President Sergio Mattarella only three months in advance, on the 27th of June. A key aspect of the election campaign was the presence in the political debate of the term "nuclear," with GoogleTrends showing that the term was searched as much as the term "immigration" (an evergreen topic in Italian politics) during the election campaign, and GoogleNews revealing >1500 news published during the 3-month campaign. Even considering the use of the term for clickbait purposes, it seems clear that the word has penetrated the electoral debate, and it has done so with two different declinations: regarding the use of nuclear power for civilian use and the escalation of the geopolitical situation in Ukraine, with the fear of an atomic conflict.

The nuclear energy debate started in late 2021 with the discussion of the introduction in the European Taxonomy for Sustainable Activities of both nuclear power and gas. The topic was initially followed by specialized print before obtaining the attention of prominent national newspapers. On the 1st of January 2022, the European Commission started consultations with experts in the field. On the 2nd of February 2022, they presented the "Taxonomy Complementary Climate Delegated Act" that included gas and Nuclear as sustainable sources for decarbonization. Italy has a tormented relationship with nuclear energy, with two referenda against nuclear plants in 1987 (after the Chernobyl disaster) and 2011 (after the Fukushima-Daiichi accident). Literature regarding Italian relations with nuclear power mainly treats the argument from an energetic and environmental point of view (Contu et al. 2016; Bersano et al. 2020) or focuses the attention on the debate right after or before the accidents of Chernobyl (Santarossa, 1990; Belelli, 1988) and Fukushima (Standish, 2009; Butler et al. 2011) mainly focusing the attention on traditional media (Bernardi et al. 2018).

Recently, the term nuclear has also been associated with chronicles regarding the scenario of an atomic conflict. The debate was raised with the start of the Russo-Ukrainian War, which saw the direct and indirect participation of countries with the largest atomic arsenals (Green, 2022). Another episode that raised attention was the battles between the Ukrainian and Russian armies to control two nuclear power plants: Chernobyl and Zaporizhzhya. There are multiple views regarding the possibility of atomic conflict among political actors (Barel, 2022; Sethi, 2022) and the broader public (Riad et al. 2023). On the one hand, some experts argue that the nuclear weapons possessed by both sides act as a deterrent. On the other hand, some advocate the possibility of using tactical nuclear weapons with "limited" destructive power. An evident aspect remains the perception of nuclear power shaped by the geopolitical situation, which has been debated since the beginning of the Ukrainian conflict (Green, 2022).

Studies on Nuclear debate that involve social media platforms (Kim and Kim 2014; Tsubokura et al. 2018) refer to the Japanese debate after the Fukushima-Daiichi incident and rely on methodologies based on text analysis. Generally speaking, Twitter has been the subject of extensive research regarding how social media have shaped society, politics, and public opinion (Jungherr, 2016). An important aspect is that even if studies have demonstrated that users are not representative of the general population (McGregor, 2019) and are highly influenced by political players (Weeks et al. 2017), academics and journalists rely on Twitter as a source of public opinion. The reason is that it has been recently demonstrated that ideas and issues represented on Twitter still provide insight into what every day citizens think (van Klingeren et al. 2021). By focusing on high-level attributes that transcend specific technologies when examining social media uses and outcomes, insights from studies of one platform can be understood in the context of other media that share the same affordances (Ellisona and Boyd, 2013). Being aware of that, we aim to apply similar approaches to different platforms, using Twitter, Facebook, and Instagram as starting points to explore the cross-platform dynamics. We aim to individuate narratives and users that convey information by connecting different social media platforms using *bridges*. A *bridge* is a concept from the transmedia theory we adopted to describe the narrative connection between social media platforms. Every platform today can be used with other communication channels and social media platforms (Boczkowski et al. 2018). Users inside this ecosystem can select the preferred tool to meet their communicative goals, creating a customized social media ecology (Bayer et al. 2020). We try to deal with the fluidity of social media platforms and their continuously evolving, adapting, and mimicking other platforms' affordances, making it hard to define a status quo.

Our goal with this research is to focus on the spread of disinformation between platforms during the Italian electoral campaign, with particular attention to nuclear thematics. For simplicity, we use disinformation as an umbrella term to refer to any information one could encounter online that could lead to a factually incorrect view of the world (Wu et al. 2019). The term includes conspiracy theories, fake news, unverified information, rumors, and hyper-partisan news. The questions we aim to answer are the following:

RQ1) Considering the *nuclear* debate on social media during the Italian electoral campaign, which kind of content has been vehiculated by bridges and for what purpose?

RQ2) Considering debates such as nuclear energy and the atomic conflict, what has been the role of bridges for disinformation dissemination dynamics inside the social media ecosystem?

We found primary evidence on mainstream platforms that political actors and activists discuss nuclear energy for civilian use. The debate about the contemporary geopolitical situation is fueled by daily users who, in the name of citizen journalism, bring attention to hyper-partisan news channels, fake news, and damaging disinformation. Challenging aspects are bridges to "non-mainstream" platforms with different affordances and dynamics that should be carefully considered to assess whether

and how they can isolate users' views at the expense of serendipity. Information disseminated through bridges can be described as affective, defective, and infective. Affective means actors support their arguments with emotional and/or fear-mongering content. Defective means that the information shared on communication channels is biased, potentially leading the audience to biases. Infective means that the content conveyed has the potential to go viral. All of these adjectives should prompt us to rethink the informational well-being of today's society.

Methodology

We consider a model of social media discussion called the Trench Warfare Dynamic (Karlsen et al. 2017). In this model, user interaction depends on each social media platform's characteristics, affordances, and elements: liking content, reacting, sharing, commenting, and linking. All these options represent different "weapons" that users can employ in the discussion. Nowadays, the variegated social media ecosystem, with many different platforms (social networking sites, videosharing platforms, messaging apps, etc.) and their different affordances, is a crucial aspect of online dynamics. Each platform today can be used with other communication channels and social media platforms (Boczkowski et al. 2018). Users within this ecosystem can select the preferred tool to meet their communication goals, creating a personalized social media ecology (Bayer et al. 2020).

Hyperlinking is a feature present in all social networking platforms, where an ordinary dynamic is the ability to share links or references that lead to content on another social media network. The use of this resource is an intentional act (Ryfe et al. 2016) that creates networks (Fu and Shumate, 2017) and an interconnected media environment (Singer and Franklin, 2019) that influence how users find, consume, and share news (Martin and Dwyer, 2019). The literature on cross-platform analysis has focused on standard hyperlinks considering news consumption (Park and Kaye, 2020; Del Vicario et al. 2017) or analyzed cross-platform dynamics among social media sites from the perspective of the user account (Amara et al. 2023; Gruzd et al. 2018). Through their role in information dissemination, hyperlinks can make sense of social phenomena in their digital dimension due to their centrality in the digital environment (Hsu and Park, 2011). Our goal is to contribute to studying hyperlinks as objects for multiplatform dynamics by applying a transmedia perspective. Defining hyperlinks as Bridges will help add nuance regarding the narrative construct that draws people to secondary platforms. Bridging is a concept from transmedia theory where the term was first used by Gary Hayes (2006) to describe the movement of audiences across different media platforms. We will use it to describe the connection between social media platforms, considering the digital object and the narrative built around the object that drives people to other platforms.

Our research relies on Digital Methods (Rogers, 2019) to collect and process data from our main platforms (Twitter, Facebook, and Instagram). Digital methods are research strategies that analyze natively digital data from web platforms to repurpose the information to represent collective phenomena, social changes, and cultural expressions. The fundamental concept on which digital methods analysis is based is that of native digital object (NDO). NDO are the objects that shape and attribute their peculiarities to the Social Media platform, such as users, links, and comments. However, they can also be a peculiarity of a specific platform: peculiar entities on Twitter are hashtags, retweets, and mentions, while on Facebook, we have likes, reactions, and pages. These digital objects should not be seen as empty but as they conceal a specific meaning. Likes and reactions can be read as sentiment indicators, retweets can be used as a yardstick for evaluating the content, hashtags should not be seen as mere labels but represent a clear message, and the number of shares of hyperlinks estimates the reputation that certain content enjoys. When used as bridges, hyperlinks represent a connection with a particular goal, allowing users to shift their attention to a different platform. We will select and study bridges that led users from primary to secondary platforms.

The methodological approach will follow an explanatory sequential design (Creswell et al. 2011) that presents a quantitative phase followed by a qualitative phase that further explores something (the bridges) discovered during the quantitative analysis. The quantitative part consists of designing a robust query for our research, collecting and systematizing the data, and finally, pre-processing the data to identify bridges between platforms. After the bridge identification phase, we will move to a fundamental qualitative phase, manually exploring content and moving between platforms to gather new information and enrich data. The elasticity of a qualitative approach can provide the possibility to gain insights, becoming essential in exploring a highly dynamic environment such as social media. Finally, we will visualize our results with dedicated software.

The multiplatform approach and the different possibilities offered by the analyzed social media networks force us to follow slightly different paths in the data collection and analysis phases, which will be explained in detail below.

Data collection. The first step of data collection is to define a query design that considers the topic's nuances and details by determining the correct keywords and their combination to allow us to interrogate the database and collect reliable and consistent data to analyze. In our case, we defined two queries, one referring to nuclear energy and atomic conflict (Q1) and the second referring to Italian electoral elections (Q2). The final query (Q_f) will be the intersection of the previous ones, which allows us to strictly select the topic "nuclear" debated in the context of "Italian elections" (Fig. 1).

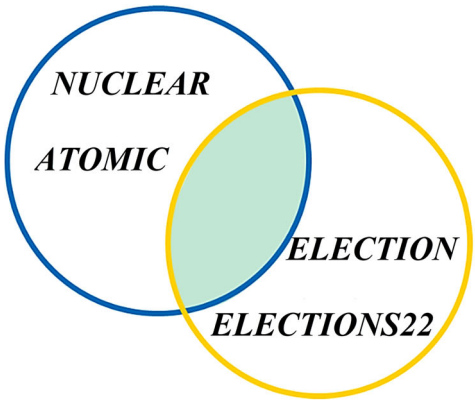
The second step consists in capturing data. To collect data from Twitter, we relied upon 4CAT (Peeters and Hagen, 2022) using Twitter's APIs for Academic access. Differently, to collect data from Facebook and Instagram, we used CrowdTangle Team (2022). The first difference is that Twitter allows data collection from every user, while Meta only gives access to the public content from verified accounts, public pages, and public groups. This difference highly influences the dataset's dimension.

4CAT allows us to upload external datasets, so we uploaded both datasets from Facebook and Instagram on the platform to start our pre-processing data phase.

Pre-processing. In this phase, which we can call bridge detection, we filtered (using a 4CAT function) every dataset by keeping only the posts containing Urls, which represent the connections towards other generic platforms and/or sites. From 4CAT, we exported our remaining data on a spreadsheet that we searched with accuracy, realizing a second-level filter by manually flagging only the connections towards other social media platforms, considering the categories below (Table 1):

As we can see above, we also included landing pages that can contain bridges directed on many different platforms.

Data enrichment, analysis and visualization. Being the analysis structured with an explanatory sequential design (Creswell et al. 2011), we moved from the quantitative step (which detected the bridges) to the qualitative step by formatting the spreadsheet to ease the exploration of the content and label data with additional information. Qualitative bridge analysis, which consists of empirically exploring content in search of new information to



$$Q_f = Q1 \cap Q2$$

Q1: nucleare OR nucleari OR atomico OR atomica OR atomici OR atomiche

Q2: elezioni OR #elezionipolitiche2022 OR #elezionipolitiche22 OR #elezionipolitiche OR #elezioni2022 #elezioni22 OR #politiche22 OR #politiche2022 #voto2022 OR #voto22 OR politico OR politiche OR politici OR politica OR salvini OR lega OR letta OR pd OR calenda OR renzi OR meloni OR fratelli italia OR conte OR movimento stelle OR di maio OR impegno civico OR berlusconi OR forza italia OR bonelli OR sinistra verdi OR bonino Europa

Fig. 1 Query design intersection structure. Q1 contains nuclear references, and Q2 contains electoral references and hashtags.

Table 1 Platform classification.

Element	Example
Mainstream Social Networking Sites	LinkedIn, Reddit, Tiktok, Facebook, Twitter, Instagram etc.
Not mainstream Social Networks	Mastodon, gab, 4chan, Vkontakte
Instant messaging service platforms	Telegram
Video-sharing platforms	Youtube, Twitch, Bitchute, Rumble
Social media landing pages	Linktree

Table 2 Elements for data enrichment manually collected exploring bridges.

Element	Description
Content type	The type of textual and/or audiovisual content Example: Post, Video, Channel
Destination Platform	The platform where the bridge leaded the user Example: Youtube, Telegram, LinkedIn, Facebook etc.
Destination Account	The account's name (user or channel) in the destination platform
User Category	The category of the user in the main platform where we found the bridge Example: Politic, News, Activist, Alt-News, Generic, Comedian, Music
Topic	The topic discussed in the original post and/or vehiculated by the bridge Example: Nuclear Energy, Atomic Conflict, Politics, Geopolitics etc.
Position	The position expressed over a topic (when clearly defined) Example: ProNuke, No-Nuke, ProNato, AntiNato, ProRussia etc.

collect, will help us widen the net between different social media platforms, allowing us to describe the characteristics of the information conveyed, considering the nuances of transmediality that are not always found with quantitative analysis.

The additional pieces of information for the phase of data enrichment are listed in Table 2.

The classification of categories, topics, and user positions was an iterative process, driven by newly discovered information and the continuous adaptation of old parameters with new ones. For the user categories, we initially considered the ones already included in the Facebook data exported by Crowdtangle, adding and modeling new categories based on what emerged during the analysis. We finally defined *politic* (considering both individuals and party pages), *news* (individuals and channels from mainstream information), *alternative news* for non-mainstream channels, *activist* as people proselytizing on the subject with no political role or involvement in mainstream information, *generic* for individuals debating the issue with mixed perspectives, *comedian* for satiric content and *music* for music channels. Concerning Topic and Positions, a differentiation between nuclear energy and the atomic conflict narrative is necessary. The fact that nuclear energy is described as a polarizing topic in the literature led us to label it dichotomously in Pro-nuke and No-nuke positions. In our analysis, we found substantially polarized content and clearly defined positions. Regarding the atomic conflict narratives, we started from dichotomous positions, but quickly found nuances that led to distinctions between Anti-Nato, Pro-Russia or Anti-Usa, all containing distinctive peculiarities. The first describes a generic distance from Nato politics, the second also expresses an endorsement of Russia's actions, while the third expresses grudge towards USA politics. The Topic field are also presented other topics to represent the nuances of the positions in the debate under analysis. Through this step of classifying and labeling content, we can now hierarchically classify categories, topics, and user positions (Fig. 2) and qualitatively analyze content in a methodical manner.

We can now decide to focus on alternative news channels that are against NATO or compare the positions of politicians in favor or against nuclear energy, checking whether the content shared can be categorized in some way as disinformation. Disinformation is an umbrella term which refers to:

- Unverified information or rumors, information that can be described as unverified before being verified, ultimately proving to be false or inaccurate;
- Propaganda, information that is potentially factually correct, but packaged in such a way as to denigrate opposing viewpoints;
- Hyper-partisan content, is news that aims to portray a political party or its members in a positive light while mocking or blaming political opponents;
- Fake-news stories deliberately false for the purpose of raising revenue or feeding propaganda and going viral;
- Conspiracy theories are attempts to explain the causes of social and political events with claims of secret conspiracies by two or more powerful actors.

This categorization taken from literature (Wu et al. 2019; Born and Edgington, 2017; Sanovich et al., 2018; Douglas et al., 2019) helped us to recognize and qualitatively describe the content highlighting the different nuances of disinformation and how the

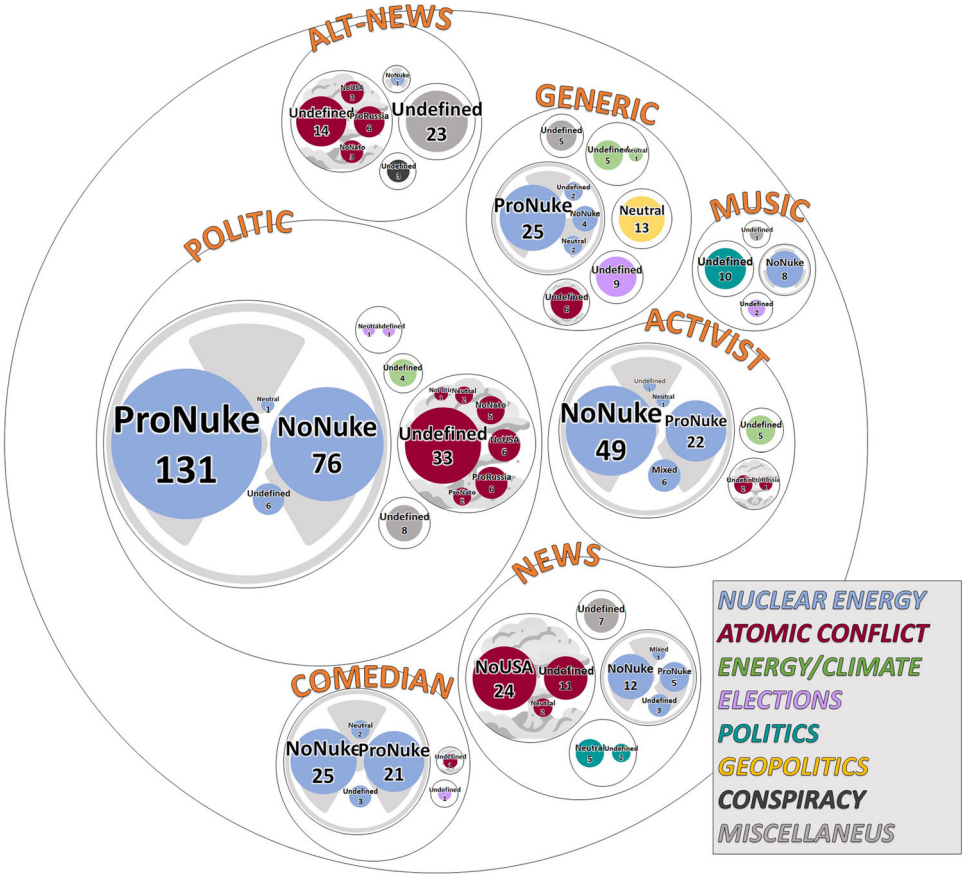


Fig. 2 Circle packing diagram. It displays values of User Category, Topic, and Positions on a hierarchical structure by using nested circles areas. Used to guide the content classification phase.

various actors at play reconciled them in cross-platform dynamics through the narrative constructs of bridges between platforms.

The classification phase allowed us to explore the content in an orderly manner and first-person "crossing bridges" from the main platforms towards various secondary platforms, reading, visualizing, and classifying a wide content sphere. This exploratory approach is meant to improve the understanding of the nuanced aspects of the topic by visiting the social environments where internet users' different points of view are located.

To visualize the data, we imported the labeled spreadsheets on Cortext (Breucker et al. 2016), creating a data corpus and using the Network Mapping feature to map together the users/channels of the primary platform with the users/channels of the secondary platforms. We exported a graph file with a .gexf extension that we managed with Gephi (Bastian et al. 2009), creating the representation visible in the Results section.

Results

We analyzed and explored 660 *bridges* (Fig. 3) from our primary platforms (Twitter, Facebook, and Instagram) oriented to secondary platforms (Youtube, LinkedIn, Mastodon, Telegram, etc.). A point that must be clarified is that a primary platform such as Facebook can become secondary when analyzing bridges detected on Twitter.

Regarding Twitter bridges, we found that the leading destination platforms are Facebook (56.88%) and Youtube (26.67%), with the third place taken by different Mastodon instances called sociale.network (n.d.) and mastodon.uno (n.d.) (8.86%). The remaining bridges connect to mainstream platforms such as LinkedIn and Instagram and below-the-radar platforms such as Friendica. Those bridges address issues regarding nuclear energy for 81% of the cases and atomic conflict for a share of 13.1%, with the remaining 5.9% that mixes different topics. On Twitter, we found different kinds of disinformation: conspiracy theories were not represented as we expected, leaving the floor mainly to hyper-partisan content and unverified information present from the narratives we investigated: nuclear energy and atomic conflict.

Bridges from Facebook are directed toward a more significant number of platforms, with Youtube taking the most share (59.78%), followed by Instagram, Telegram, and Twitter, all around 11.75%. The minor platforms linked from Facebook are the mainstream TikTok and Twitch and below-the-radar platforms such as Mastodon (sociale.network), Rumble, and Sfero. Facebook's disinformation included more content related to conspiracy theories than Twitter, with hyper-partisan content and unverified information. The ecosystem of this kind of content was more varied and oriented to different below-the-radar platforms.

Instagram bridge detection has been carried out differently from other platforms because Instagram does not allow direct links in descriptions. Most bridges have been identified with the text "link in Bio." The Bio usually contains hyperlinks or landing pages where it is possible to find different bridges simultaneously, configuring a star topology network. The bridges were directed to the same user's accounts on other platforms, and actually directed to the generic profile and not to a specific content. In this case, we crossed the platform without exposure to a different kind of more extreme disinformation content because the pages encountered usually followed the same "editorial line" on all platforms.

Nuclear energy propaganda and hyper-partisan politics. The bridges from Twitter to Facebook mostly lead to politicians

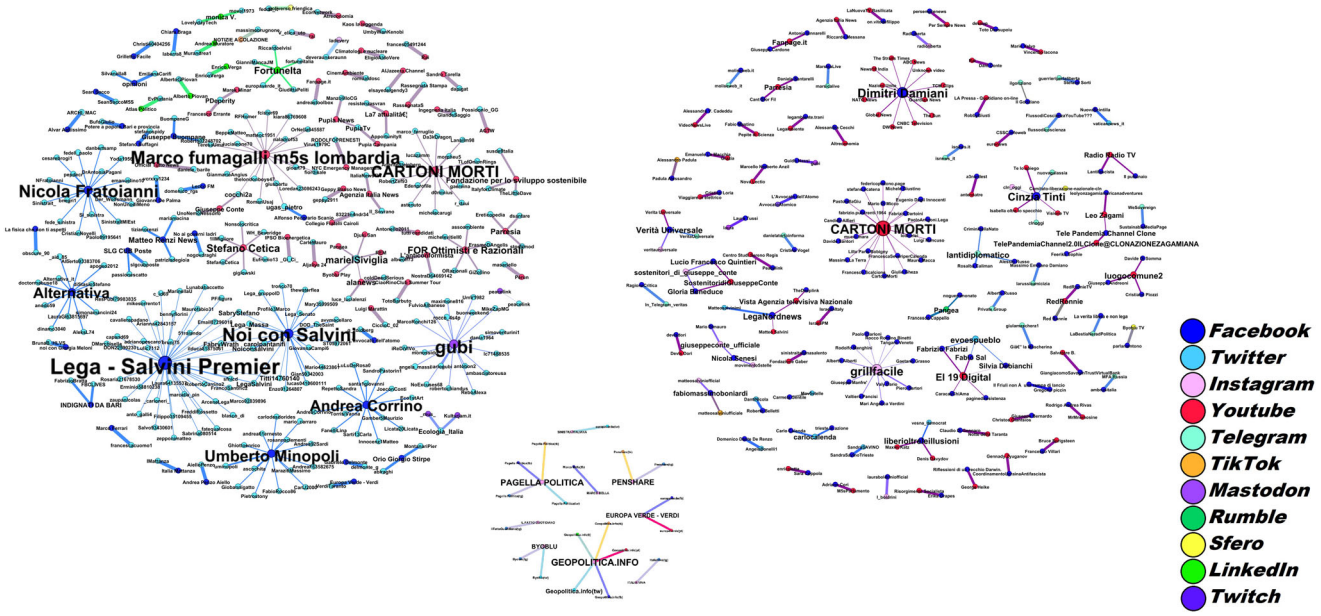


Fig. 3 Bridges graph. Realized by the author, it separately represents bridges identified in the three main platforms. The nodes represent users and/or channels/pages on primary and secondary platforms, while the edges represent the bridges. Nodes color distinguish platforms. On the left, we have the bridges detected on Twitter, with light-blue nodes connected to the users and channels of the secondary platforms, on the right we have the bridges detected on Facebook, with dark-blue nodes connected to the users and channels of the secondary platforms, and in the center we have the bridges detected on Instagram, with pink nodes connected to the users and channels of the secondary platforms.



Fig. 4 Political debate. Examples of posts from politicians and activists discussing nuclear energy for civil use contain bridges characterized by affective and defective narratives.

strongly polarized on nuclear power in both positions (Fig. 4). We find pro-nuclear energy profiles (Lega - Salvini Premier and Noi con Salvini) of the League party that has promised to restart the Italian nuclear program. The League presented the introduction of European taxonomy as a political victory against opposing parties and used a strong affective lexicon comparing environmentalists to the Taliban. The no-Nuke counterpart (5-Star Movement, Alternative, Democratic Party, and Angelo Bonelli) responded significantly against Matteo Salvini, secretary of the League. They accused pro-Nuke politicians of misleading voters with misinformation about the fourth-generation nuclear power narrative and called for a public debate on the energy issue.

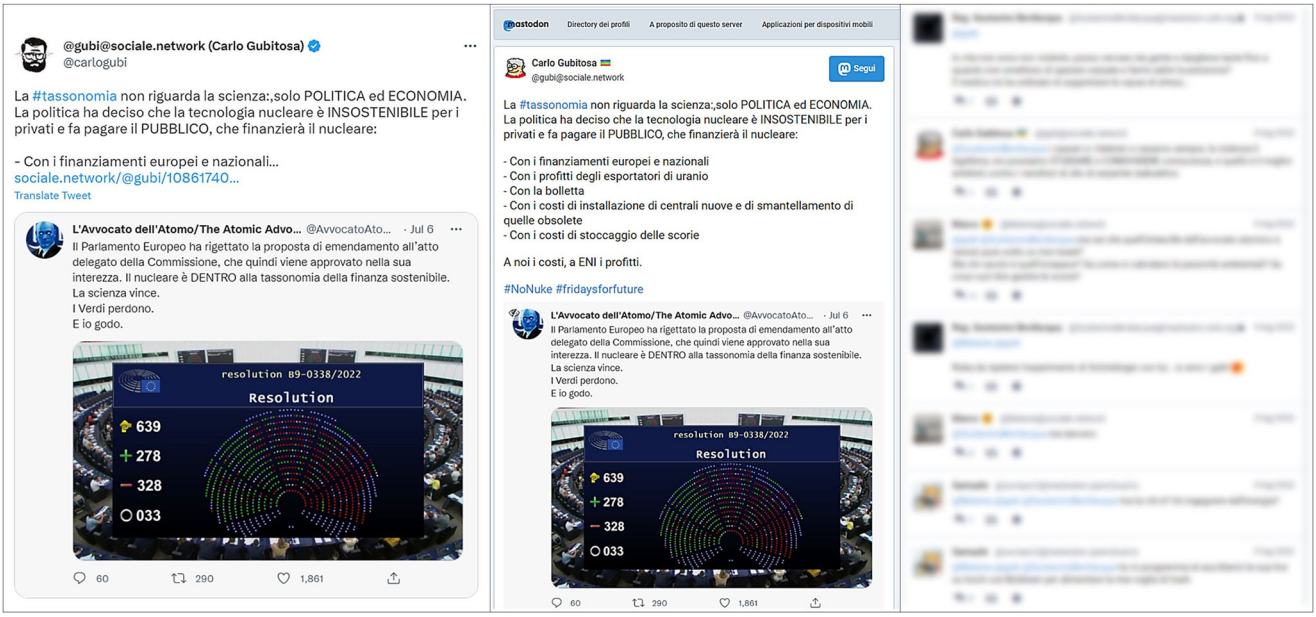


Fig. 5 Twitter-Mastodon. The image shows Twitter feed (on the left) and Mastodon feed on sociale.network instance (center). The Mastodon post recalls the tweet and shows highly polarized comments (on the right, blurred for privacy).

Lined up in both factions, we can find activists who have advocated positions for (Umberto Minopoli, n.d.) or against (Andrea Corrino, n.d.) civil nuclear power. Facebook's hyper-partisan content is usually posted with text and a single image, together with video content (especially by politicians sharing interviews during campaigning). The content from Facebook to Twitter accounts for most of the political content we identified. It is material shared within public groups with different political orientations. It mainly bridges to content from pro-Nuke politicians Matteo Salvini, Carlo Calenda, and Nicola Danti (ItaliaViva), with only a few posts referring to the no-Nuke positions of Angelo Bonelli (Europa Verde) and 5-Star Movement. Other public groups with no-Nuke positions are mainly oriented on Instagram to political profiles such 5-Star Movement and Giuseppe Conte.

The political content is polarized, with pro-Nuke parties using different approaches. On the one hand, a pragmatic approach by Azione & ItaliaViva introduced the importance of the energy mix to achieve the 2050 zero-emissions goal. Conversely, La Lega chose affective language and narratives close to people's concerns. For example, Matteo Salvini used hyperbole to advocate for nuclear energy, claiming that it would be no problem for him to have a power plant near his home in Milan or that investing in fourth-generation nuclear power is the only way to lower citizens' bills. The latter statement is factually false because it is known that the technology is not ready and is not a short-term solution. The opposition response used the same affective approach, with Giuseppe Conte (5-Star Movement) responding to Matteo Salvini's hyperbole by organizing a public debate in Milan to express his opposition to "nuclear waste and the contamination of our children's future." Other objections to pro-Nuke statements by no-Nuke parties used similar rhetorical fallacies, with Angelo Bonelli (Europa Verde) sharing a map of potential sites for nuclear power plants supposedly chosen by his political opponents. The map was false and inaccurate and was debunked by a well-known debunking site called PagellaPolitica (n.d.).

In addition to the bridges to mainstream platforms, we also found bridges to below-the-radar platforms such as Mastodon (Fig. 5), which, although not quantitatively relevant, deserve further analysis. Mastodon is open-source software that enables self-hosted social networking services. It has microblogging functions and consists of a large number of independent instances. The links we encountered are directed mainly to a particular instance called sociale.network created by users gubi (Carlo Gubitosa, n.d.), a writer and no-Nuke activist, and the Peacelink association (n.d.).

One strategy observed with these Mastodon-oriented bridges is the cross-posting of content on Twitter to open a parallel discussion on the Mastodon instance. In the case above, the debate is between Carlogubi (Carlo Gubitosa, writer and no-Nuke activist), who responded to content from L'avvocato Atomico (n.d.), a pro-Nuke activist. Regardless of the debate on the source platform, a highly polarized debate opens up on the bridge-targeted instance to which Twitter users can be directed. The bridge is a rabbit hole to a polarized social space away from open debate. Browsing the feed of this instance, it is clear that all the news shared is against nuclear energy for civilian use, creating a defective environment in what can be described as an echo chamber by design, meaning a space far from serendipity.

Video is the type of content conveyed with connections to Facebook (Marco Fumagalli m5s) and, of course, Youtube, mainly directed to channels of no-Nuke politicians (Giuseppe Conte of the 5-Star Movement) and pro-Nuke activists (Parresia, n.d.). Along with the political content, we detected other affective approaches, such as the satirical content of user Grilletto Facile (n.d.), who jokes about pro-Nuke positions, and the ironic viral content of CartoniMorti (n.d.), who refers to Youtube in support of pro-Nuke positions.

We found a narrative that mixes elections and Masonic conspiracy theories among Youtube-oriented content. A post on the G**** Facebook page urges users to stop giving electoral consent to "political freemasonry," suggesting two alternatives: on the one hand, avoid the ballot box, and on the other hand, go to the polls and write "G****" on the ballots. The motive for these actions is justified by "becoming an active participant in the process of opposing the plan of global destruction, with nuclear weapons, starting in 2024, as explained through indisputable legal acts in this video." The video links to a 2-hour 40-minute monologue by Carlo Palermo, a lawyer, former magistrate, and politician, who explains several points in his book "The Beast. From Italian Mysteries to the Masonic Powers Directing the New

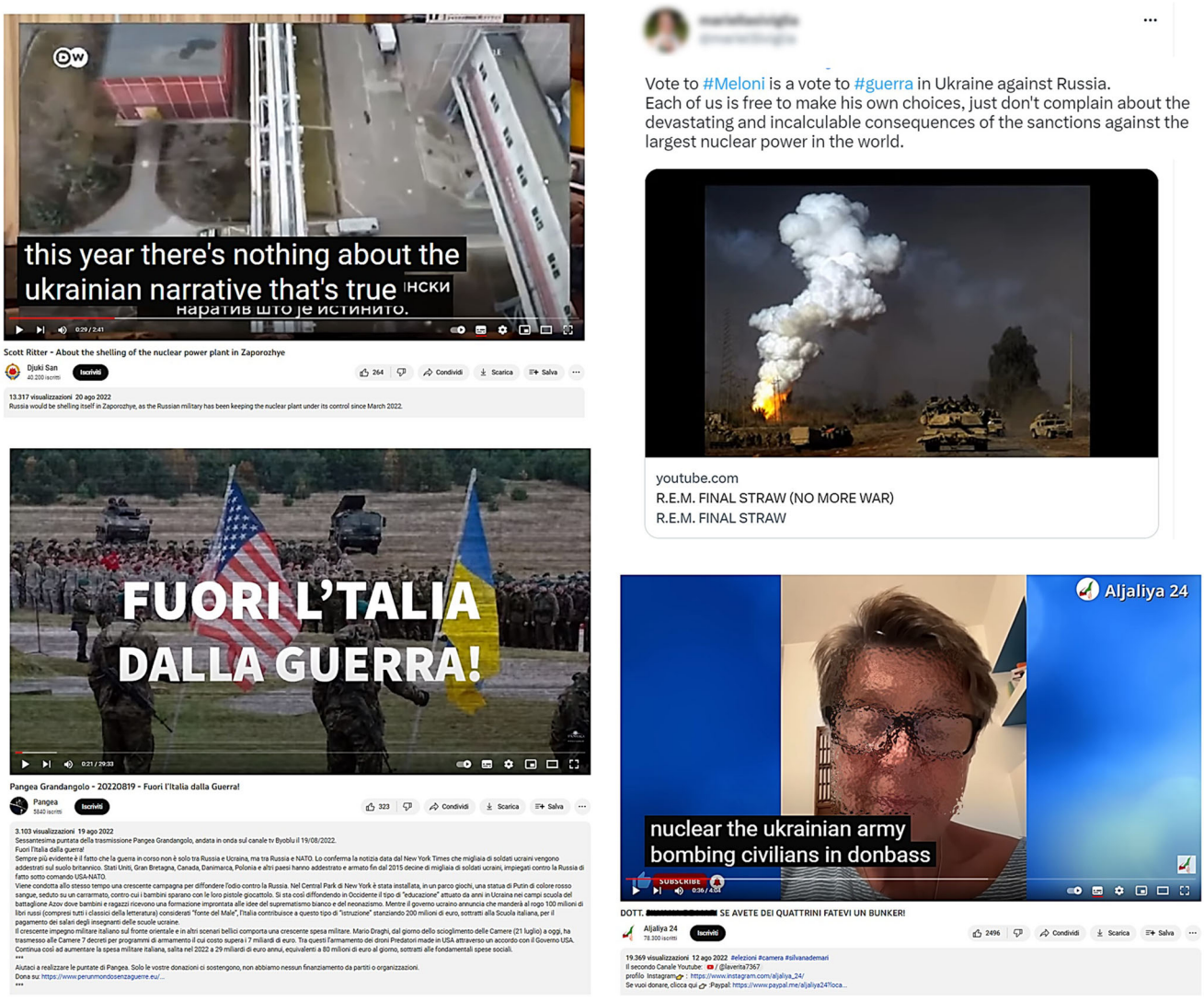


Fig. 6 Youtube-oriented videos. Content is highly polarized on pro-Russia and antiNato positions and disseminated using defective and affective narratives.

World Order," published in 2018. The video (Salvatore, 2022, Aug. 20) reinterprets historical episodes by identifying the action of freemasonry acting behind the scenes in several events, such as the assassination attempt on Karol Wojtyla in 1981, the Yalta conference in 1943, the invasion of Iraq in 1991 described as the beginning of the NWO project, and the attack on the twin towers on 11 September 2001. These contents are described as a reason to join the G****, which is "[…] an Extraterritorial Monetary Organization with philanthropic aims for the promotion of Human Rights and Fundamental Freedoms […] having become aware of the fact that many illnesses from which a large part of humanity suffers are generated by stressors related to the constant economic difficulties resulting from the mismanagement of world finance wanted by the Integrated Criminal System that governs the world that has created a state of slavery that, at all costs, it wants to maintain in order to force all human beings on this planet to submit to it perpetually." The construction of the conspiracy seems structured to force people to participate in some monetary scam, and the bridge with Youtube is part of this mechanism to tease people into believing the alternative narrative.

Atomic conflict rumors and conspiracy theories. Most of the content passing through Youtube is related to news and information channels that focus mainly on the atomic conflict narrative, with several channels sharing geopolitical news/rumors and commentary to express their positions (Stefano Cetica, n.d.). Among Youtube content, it was possible to identify conspiracy and hyper-partisan channels (Byoblu[3] Play, Pangea, n.d., Djuki San, n.d., and Aljaliya 24, n.d.) that advocate pro-Russia and anti-NATO positions (Fig. 6).

Analyzing this content we crossed different narratives and rhetorical approaches. Some bridges lead to content opposed to NATO and "the Ukrainian narrative," providing a hyper-partisan version of the battle for control of the Zaporizhzhia power plant. Other content seeks to position itself in a more neutral perspective, declaring itself opposed to the war and claiming to want Italy out of the conflict. This "pacifist" narrative is also exploited from an electoral standpoint to politically attack parties that expressed support for Ukraine during the election campaign. In some cases, attempts have been made to convey messages with affective and emotional content, for example, by accompanying them with music, as in the case of R.E.M.'s song entitled "Final Straw, No More War." Finally, there is the more extreme content of full support for the Russian cause that uses hyper-partisan news and alarmist tones, bragging about the outbreak of an atomic conflict and suggesting that the public build their atomic bunker. Browsing and exploring

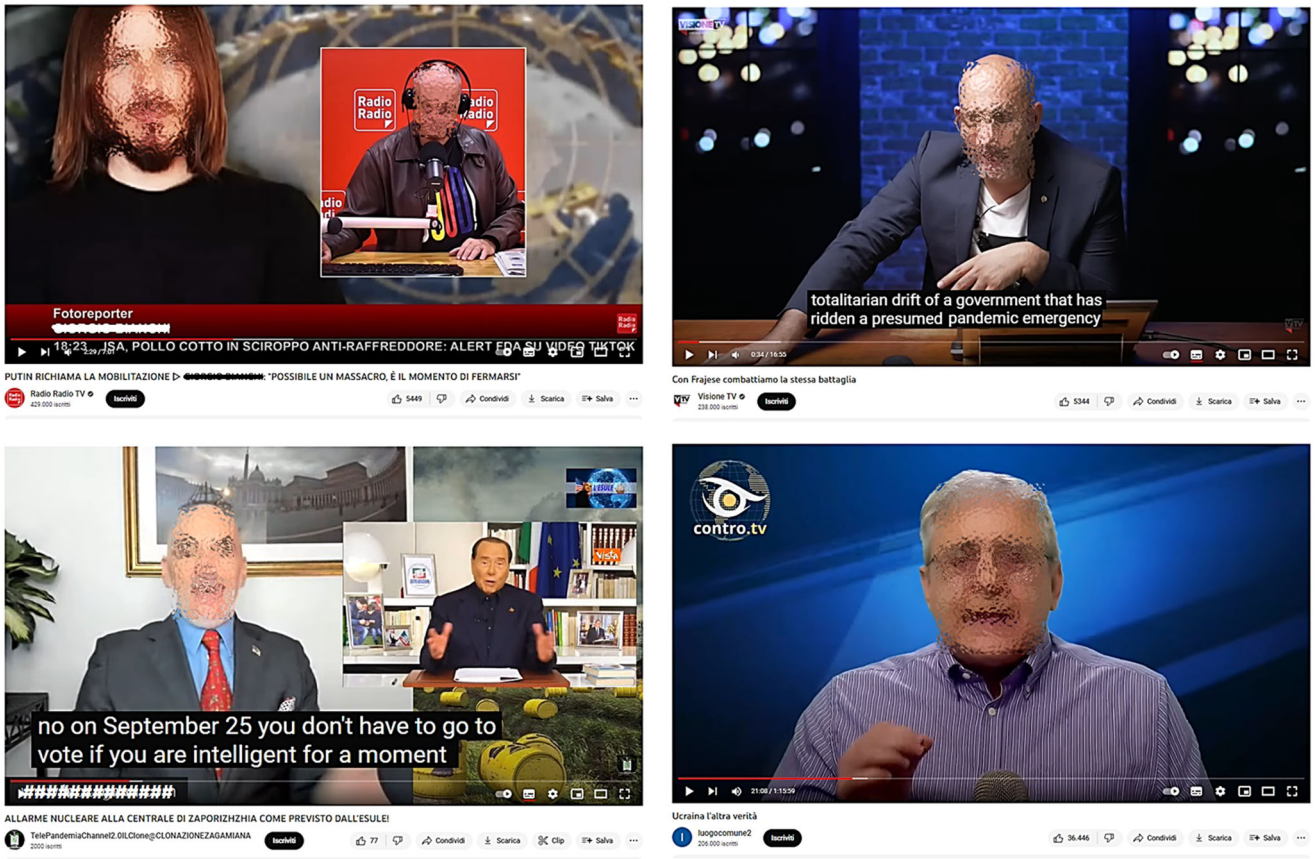


Fig. 7 Youtube-television. Conspiracy content, which highlights the mimicking of mainstream information.

these highly polarized circles, we found defective positions that support Vladimir Putin's actions (TV Radio). Among these extreme positions, we can also find conspiracy content on several channels (LeoZagami, n.d.[4], TelePandemiaChannel, 2022, RedRonnie, VisionTV, and luogocomune2, 2022).

These channels deal with the narrative of the Russian-Ukrainian war but also shift the focus to other topics such as the Covid-19 pandemic (Vision TV, 2022, min 0:30), aliens and religion (RedRonnie, 2022, min 5: 45), Freemasonry and the New World Order (TelePandemicChannel, 2022, min 21:20). They also convey messages against mainstream media (luogocommune2, 2022, min 1:35) and national and international political institutions (RadioRadioTV, 2022, min 1:20). They have in common the imitation of journalistic style toward information, with fake news and disinformation masquerading as authoritative content (Fig. 7). In addition, the names of the different channels refer to television (TV and Tele) to equate with the traditional media in an attempt to gain the same credibility with the public.

Notably, the alt-news profiles usually had a more complex social media ecosystem, with the example below (Fig. 8) showing eight different social media platforms systematically referenced and linked to each other in what appears to be an attempt to generate infectivity and virality. To attract people to the defective content, platforms such as Bitchute and Rumble are described as free from censorship and used as a backup for video content banned by Youtube. Other conspiracy content was present in other below-the-radar platforms such as Gab (known to have a far-right community), Mewe (whose tagline reads "imagine a place where you trust your social network"), and, finally, messaging apps such as Telegram.

Conspiracy content is quickly delivered by Telegram (Nuovagalassia, n.d., WeSovereign, Lantidiplomatico, n.d.,

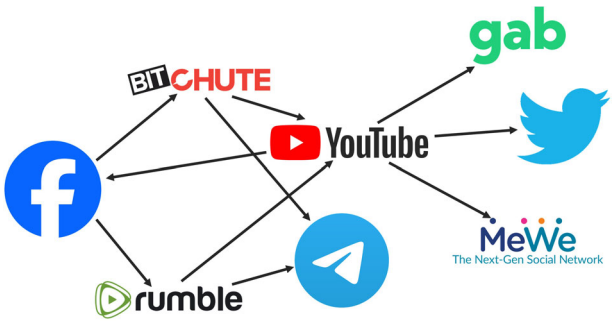


Fig. 8 Platform ecosystem. The graph shows the mix of mainstream and below-the-radar platforms.

LaBestiaNeradPolitica, n.d., In_telegram_veritas, n.d.), Rumble (Pangea, n.d.) and Sfero (Byoblu TV, n.d.). Telegram, characterized by the immediacy of communication, becomes fertile ground for factually interpreted news, and most content can be recognized as unverified information and rumors. Bridges on Telegram are rarely directed at a particular post but usually refer to the entire channel. In the image below (Fig. 9), we can appreciate the mood of some channels regarding the Russian-Ukrainian war. The WeSovereign channel uses alarmist tones announcing the approach of World War III. In contrast, the infective Lantidiplomatico channel (with nearly 90,000 subscribers) posts news of a new military aid package for Ukraine from the United States, registering polarized reactions (visible in the post below) that are 93% [vomit] and [anger]. Finally, the In_telegram_veritas channel refers to Zelensky as "the Ukrainian comedian," accusing him of profiting from the episode of Russian missiles allegedly flying over

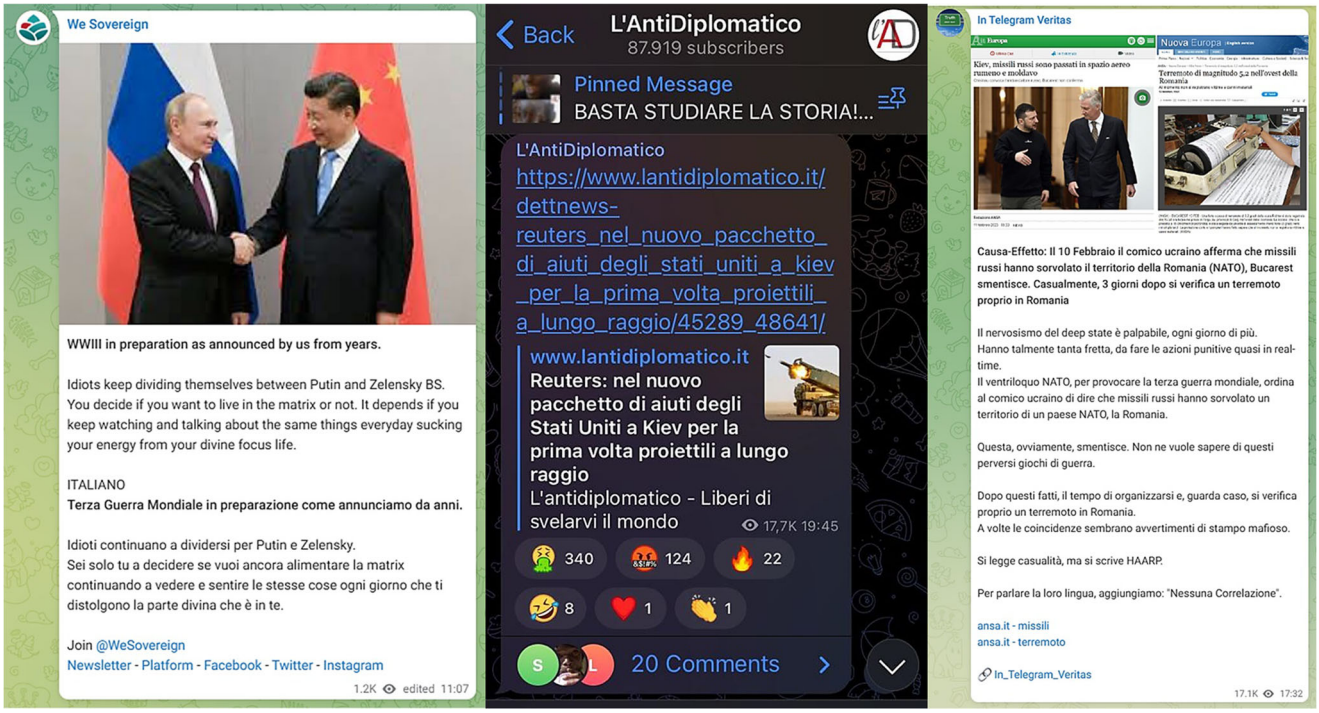


Fig. 9 Telegram content. Channels with infective disinformation and partisan content are able to reach more than 35,000 users in total.

Romanian (and so NATO) territory (Kudrytski & Vilcu, 2023). Romania denied the violation of its airspace, contradicting the Ukrainian claim. The defective channel invented a correlation with the June 6 earthquake in Romania to "mafia-like warnings" from NATO caused by the HAARP project.

Bridges to below-the-radar platforms have often shifted the focus to channels rather than specific content, as in the case of the Pangea channel on Rumble and the Byoblu channel on Sfero. Both channels are a conglomeration of disinformation, hyper-partisan and fake news, anti-scientific narratives, and conspiracies. Rumble is a video-sharing platform popular among American right-wing and far-right users and has been described as part of the "alt-tech" by several observers (Munn, 2023). Sfero is an Italian social media created in opposition to censorship on mainstream platforms that, with its blog-like structure, allows users to publish content without fact-checking or debunking.

Finally, a peculiar fact is the conspiracy-minded Instagram profile Byoblu, which, along with bridges to other social media platforms, also invites the public to follow them on mainstream television by mentioning their TG Byoblu24 on various satellite TV channels.

Discussion

The debate on nuclear power revealed the predominance of political actors particularly active in propaganda about the pros and cons of power plants. In addition to them, activists reinforce politicians' statements in both directions, with only a few instances of non-partisan approaches, such as Pagella_Politica on Instagram, which debunks content from all political sides, and informational approaches, such as CartoniMorti and Parresia on Youtube.

The narratives of ordinary users described a fragmented situation, especially concerning the narrative of the atomic conflict. On the one hand, people supported the Ukrainian cause, especially regarding humanitarian aid. On the other hand, ordinary people expressed doubts about the role of the United States and NATO in the conflict, showing divergent ideas about the role Italy should maintain in the geopolitical scenario. Moving to the extremes, some users expressed an even more drastic position, supporting Putin's actions and condemning Western countries.

In response to our RQ1, we can describe the content conveyed by bridges in the electoral debate regarding nuclear narratives with three adjectives: affective, defective, and (potentially) infective.

First, affective means that political actors (politicians, journalists, and political influencers on social media) tend to support their arguments with emotional and/or fear-mongering content. This rhetoric is easily pursued with the atomic conflict narrative but infuses discourses on nuclear energy. This is the case with the debate we saw above between Matteo Salvini and Giuseppe Conte on the Milan nuclear power plant or the persistent reference to the danger of a third world war by disinformation channels. Another peculiar aspect we found is the presence of messages conveyed with Youtube music content, which seems to be an attempt to exploit the mood and words of music to deliver a message.

Second, by defective, we mean that the information shared on some communication channels is partisan, unverified, or completely false, potentially leading the public to biases that can confuse and shift opinion. This is the case with politician Angelo Bonelli, who shared inaccurate information about potential sites for power plants, or Matteo Salvini, who falsely presented fourth-generation nuclear power as a ready-made technology. More defective content related to the geopolitical scenario can be found on the hyper-partisan and conspiracy channels we identified, such as Sfero's Byoblu channel, YouTube's LeoZagami channel, and the public Telegram groups In_telegram_veritas, Wesovereign, and Lantidiplomatico, among others. In the latter case, a distinctive aspect of bridging is that the destination platform is usually presented as a trusted source exposing news hidden from mainstream news outlets.

Finally, infective means that the content conveyed has the potential to go viral due to the multiplatform dynamic and effectiveness of the content.

Speaking of infectivity, in our analysis, we found that misleading information is usually channeled with bridges oriented toward under-the-radar social networks (Sfero), video-sharing platforms (Youtube, Rumble), or messaging applications (Telegram), which make up about 50 percent of the target platforms. This could be due to their particular policies; in fact, these environments have less control over the content, as opposed to mainstream social media such as Facebook and Twitter, which, especially with the Covid-19 pandemic, have structured stricter content quality control to hinder fake news (Hartley and Vu, 2020). We found misinformation and unverified content on mainstream video-sharing platforms such as Youtube, noticing that when content was removed due to a policy violation, it was systematically uploaded to below-the-radar video-sharing platforms such as Rumble and Bitchute, described as "free from censorship" since they provide a lower level of content control.

Disinformative and propagandistic content can be found in messaging apps such as Telegram, where public channels are the central aspect that fosters the development of exclusive echo chamber-like environments. The public channel grants anonymity to content creators who can hide by showing only the channel name (Urman and Katz, 2022). This possibility seems to be appreciated by users and has prompted competitors (Whatsapp) to develop similar solutions by implementing public groups. Controversial content, even when not directly related to national elections, spreads misinformation and insidiously spreads the message that governments, institutions, and national media are hiding news from the public. By conveying and promoting a conspiratorial approach to information, this behavior potentially affects society by undermining the credibility of national and international institutions, driving people away from a balanced political life, and pushing them toward extremism (Sutton and Douglas, 2020). This is particularly relevant in a country like Italy, which has a growing trend of absenteeism in national elections and recorded the highest rate during the last elections (Damilano, 2022).

Among the platforms we discovered in the social media ecosystem of the nuclear debate during the Italian elections, some are relatively recent and were initially born to counter the spread of disinformation and highly polarized content. This is the case of Mastodon, a platform based on the open and decentralized social networking protocol ActivityPub. A peculiarity of Mastodon is that to create a profile, users must join a particular instance (which represents the actual microblogging communication space). This feature implies that entering the infrastructure directly from a rabbit hole that leads into potentially polarized environments is mandatory, with the apparent detriment of serendipity. On Mastodon, each instance has its code of conduct, terms of service, privacy policy, privacy options, and moderation policies, a feature driven by the idea that small communities can moderate their content better than large companies. Social media evolve with society, and their features adapt to the needs of the people who use them or are shaped by their use. In light of this, the original vocation did not prevent Mastodon from being forked in 2019 to use it as infrastructure for Gab (a platform with a known far-right community) and TruthSocial, a Republican-oriented platform founded by Donald Trump after his suspension from Twitter (Kan, 2021). This aspect suggests that platforms, with their affordances and policies, are not the only actors in influencing social media environments.

The presence of different platforms in the social media ecosystem alters the dynamics of information dissemination. In response to our RQ2, the role of bridges between platforms can be seen as a communicative "weapon" with multiple uses. On the one hand, bridges are used to disseminate information in order to achieve a specific communicative purpose with different strategies:

- presenting what the author considers a better or new perspective on a specific topic (with the possibility of running into propaganda news, hyper-partisan content, and conspiracies);
- convey the message with auxiliary content that prompts the mood (e.g., with music);
- imitate the characteristics of other media (alternative news channels mirroring TV news), realizing the remediation of traditional media conceptualized by Bolter and Grusin (2000).

On the other hand, they pursue a secondary goal related to media ecology, seeking to bring audiences into favorable environments for speakers. A favorable environment indicates an online space in which the affordances of the platform (likes, reactions, comments) return positive feedback on the content being conveyed, as, for example, Mastodon's feed on the istance sociale.network in which all the voices and comments were polarized on the no-Nuke positions.

Conclusions

In this multiplatform research, we explored different social media environments and their cross-platform dynamics to navigate the Italian electoral debate, focusing on disinformative content related to the nuclear narrative. Crossing the bridges between platforms showed an ecosystem made by different actors and narratives bound together.

The main limitation of this study is that Facebook and Instagram content comes only for public pages, public groups, and verified profiles due to Meta's policies on privacy. However, it should be emphasized that content shared in Facebook public groups and pages usually comes from profiles belonging to everyday users, allowing us to have a representation of this type of users in our datasets. A second limitation is also related to textual analysis of Instagram content which is usually more audiovisual-centered. Also, due to a change in Instagram policies since 31st July 31st, 2022, all videos under 15 min are classified as reels and not supported by CrowdTangle APIs. Therefore were not available in our research results.

This paper aims to highlight the complexity of today's social media ecosystem in the dynamics of disinformation dissemination, showing the interlacing of mainstream and below-the-radar platforms, with important roles played by video-sharing platforms and messaging apps. Following Bruns, Harrington, and Hurcombe (2021) suggestions, the elastic research design is oriented to investigate "the key inflection points where the spread of such disinformation can be reduced" (Bruns et al. 2021). The research provides an original hybrid technique for cross-platform analysis that brings together the robust approach of thematic research with approaches that rely on seeking one or more digital objects shared across platforms such as hyperlinks (Rogers, 2023). The step which goes beyond the existing body of knowledge, is the application of a transmedia perspective by defining the concept of Bridge. The aim is to add a further key to the cross-platform analysis by emphasizing the narrative device that drives audiences to secondary platforms.

The paper contributes to analyze the political debate on nuclear-related themes, which are not frequently investigated in the literature concerning Italian electoral campaigns, and responds to the call to broaden analysis of political communication in the field of multimodality. The article complements discussions on the affective nature of communication in participatory social media ecosystems (KhosraviNik, 2018; Sakki and

Martikainen, 2021; Laaksonen et al. 2022) by suggesting that while the particular discourse studied is not generalizable, many of the discursive strategies observed are more general in nature and have been found in different contexts. Furthermore, the focus on defective content underlined the dynamics peculiar to the broader social media ecosystem, which focuses on below-the-radar or fringe platforms (Rogers, 2021). Content analysis shows environments where there is a clear overexposure of disinformation content: while Telegram channels facilitate and speed up the transmission of unverified rumors and information, the observation of particular environments (Rumble, Bitchute, and Sfero) denotes the presence and circulation of countless alternative information channels.

Finally, I would like to emphasize the importance of shedding light on the 'below the radar' platforms when adopting policies to counter disinformation. The recent European Digital Services Act (Leiser, 2023), is an important step that does not, however, take into account the 'below the radar' environments (even Telegram is excluded from the list of Very Large Online Platforms). The risk in this way is to chase technology trying to remedy already corrupt environments. A suggestion is that it might be productive to investigate and regulate these fringe communication spaces from their genesis, before they become mainstream and it is already too late.

Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to the nature of social media data containing potentially sensitive information. Data is aggregated and available in the supplementary information files for review purposes. Data has been collected through Twitter API's and Meta dashboard for researchers Crowdtangle.

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Notes

1 Data relating to the Italy area only for the Chamber of Deputies; the percentage, therefore, does not include the Abroad electoral district.

2 The right and conservative coalition was formed by LaLega party led by Matteo Salvini, Fratelli D'Italia led by Giorgia Meloni, Forza Italia led by Silvio Berlusconi, and Noi Moderati led by Maurizio Lupi. The left coalition was formed by Partito Democratico led by Enrico Letta, Alleanza Verdi-Sinistra led by Angelo Bonelli, Impegno Civico led by Luigi Di Maio, and +Europa led by Emma Bonino. The Movimento 5 Stelle party opted to participate alone in the electoral round and a third coalition was composed by Azione led by Carlo Calenda and Italia Viva led by Matteo Renzi. The significant victory of the right and conservative coalition brought Giorgia Meloni to the position of Prime Minister, becoming the first woman ever to hold this position in Italian Republican history.

3 Byoblu is an alternative news channel created through crowdfunding that is now structured as a news agency with around 40 employees. It has distinguished itself over the years for populist and anti-European positions, scientific theses not recognized by the scientific community, anti-vaccinationist positions and conspiracy theories such as the Kalergy plan (Rizzini & Canettieri, 2021).

4 Zagami is dedicated to study and research in the esoteric, historical and philosophical fields. In 2006, Zagami began his web activity concerning his direct involvement with the New World Order and the Secret Societies commonly known as the Illuminati. Since 2009, he has authored four essays and geopolitical books.

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Author contributions

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

Competing interests

The author declares no competing interests.

Ethical approval

All procedures performed were in accordance with the ethical standards of the institution and with the 1964 Helsinki Declaration and its later emendament or comparable ethical standards.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

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Mapping the digital politics: Spatial dynamics of the National Radioactive Waste Depository debate in Italy.

Abstract

Radioactive waste operates in a profoundly different temporality and, due to its longevity, marks our future for millions of years. In Italy, the public debate for a National Radioactive Waste Depository project involving seven different Regions has strongly mobilized public opinion.
This contribution approaches the radioactive waste topic from a spatial perspective that delves into the dynamics of actors, networks and issues with the aim of capturing the spatiality of digital public spheres. The methodology combines digital tools with spatial analysis to analyze social media data using a quanti-qualitative approach.
The results show a public sphere dominated by political actors, local news channels and activists contributing to a hyper-partisan debate that disrupted the digital public sphere. The issues debated on the one hand underline the peculiar dimension of the debate as the regional one, leading to coining the acronym NIMYR (Not In MY Region), and on the one hand transcend spatio-temporal boundaries.
The paper presents a nuanced description of the radioactive waste controversy, showing a promising avenue for understanding complex social phenomena and exposing the implications of the unregulated development of this debate in the digital ecosystem, highlighting the importance of well-structured communication strategies to avoid stalemate or public conflict.

Keywords: Digital Public sphere, Issue spatiality, Radioactive Waste, Digital Methods, NIMYR.

1. INTRODUCTION

The sociologist and philosopher Zygmunt Bauman in his book *Wasted lives* (2004) highlights the acute crisis of the human waste disposal industry by stating that "Our planet is full", which refers to the disappearance of "no man's land" that for greater part of modern history played the crucial role of dumping grounds for human waste. In particular, radioactive waste operates in a deeply different temporality, being a material whose toxicity needs a different conceptualization of time (Wyck, 2004).
The products of nuclear technologies have ended and started international conflicts, saved and ended lives, and promised cheap energy for a brighter future (Melchionda, 2023). Because of longevity, radioactive material puts a mark in our present and in the future for millions of years, providing a time-stamp for this kind of human impact on planet Earth, and leading some scholars to rename this period as "Nuclear Anthropocene" (Wyck, 2004). Nuclear landscapes have blurred boundaries that contain elements related to military arsenals, power plants, decommissioning facilities, radioactive waste depositories, and communities of people living nearby. This contribution focuses particularly on the last two points.

In Italy, the 4th of January 2021, a breaking news reached national magnitude among the public opinion in relation to radioactive waste management: Sogin (the public company that manages nuclear waste in Italy) published documentation and the project for a National Radioactive Waste Depository (from now on National Depository). Among the documents a map called CNAPI (Carta Nazionale Aree più Idonee - National Map of Most Suitable Areas) has been published, showing to the public the areas with potential idoneity to host the National Depository. The involved Provinces are 13, with 67 different locations that are classified as "Solid candidates" (12 areas), "high interest" (11 areas) and "less interesting" (44 areas).

The National Depository[1] is a surface environmental infrastructure that will allow for the permanent safe storage of radioactive waste, now stored within dozens of temporary depositories across the country, produced by the operation and decommissioning of nuclear facilities and the daily activities of nuclear medicine, industry and research. It will consist of the facilities for the disposal of low-level and medium-level radioactive waste and those for the temporary storage of high-level radioactive waste, which must be later transferred to a European Depository suitable for their final disposition (Moffett, 2014). The National Depository will also shelter waste currently stored in temporary depositories that come from non-energy sources, i.e., from scientific research, industry and nuclear medicine, which inevitably will continue to be produced in Italy (Deposito Nazionale, n.d.). The publication of the map has mobilized public opinion with the debate fueled by national and local politicians, ecologists organizations (Legambiente, WWF and Greenpeace among others), NIMBY (Not In My Back-Yard) committees and common people.

This article examines the public debate on radioactive waste among Italian social media users, a conversation that intersects with politically significant themes such as environmental sustainability and economic policy. It draws on the premise that digital and physical experiences are not separate spheres but are deeply intertwined (Jurgenson, 2012). Social media users often engage in political discourse in ways that are rooted in their offline relationships and local concerns, including neighborhood-level issues and community dynamics (Neely & Collins, 2018; Hagen et al., 2017). The analysis focuses on the six-month period following the publication of official documents, emphasizing the importance of when information is disseminated. The timing of communication—whether before, during, or after a key event—can activate different interpretive frames (Chong & Druckman, 2007), significantly shaping public perception and influencing decision-making processes. Moreover, the temporal dynamics of social media affect not only interpretation but also the reach and impact of information, as timeliness often determines visibility and virality in digital environments where speed frequently overrides accuracy (Bruns, 2018).

Given the predominantly local nature of the debate, fueled by the controversy over the National Depository, the topic seems appropriate being approached from an Issue Spatiality perspective (Stoltenberg, 2021).

Issue spatiality is built upon Martina Löw's (2008) sociology of space, which combines structure-theoretical arguments about space's power to originate social events with action-theoretical considerations about space being the result of action, suggesting a duality of space. It represents the idea that social (communicative) action produces space, which in turn forms social action

[1] The European Union (Article 4 of Directive 2011/70) requires that final disposal of radioactive waste take place in the member state where it was generated. Most European countries have or are in the process of establishing depositories to secure their very low and low-level waste. In order to permanently settle medium- and high-level waste, some European countries, including Italy, have the possibility to study the location of a common deep (geological) depository in Europe in order to enjoy the potential benefits of an optimized solution in terms of waste quantity, cost and time, as envisaged by EURATOM Directive 2011/70.

iteratively (Löw 2008). Citing academics like Edward Soja (1989), Löw (2008, p. 26) argues space does not exist as an independent 'container' in which social processes occur; rather, it develops from a process of perceiving entities as related to one another (Löw, 2008, p. 35). This relational ordering can be achieved via a pair of methods: space and synthesis. Spacing is the physical placement of actors, while synthesis is how these actors are viewed in relation to each other. Synthesis is viewed as a social and communicative process with public communication serving a crucial role (Stoltenberg, 2021). Stoltenberg's Issue Spatiality framework extends Löw's theory to address the unique spatial dynamics of political and social issues in today's interconnected world by combining the digital and physical aspects of communication.

In particular, Daniela Stoltenberg (2021) claims that the notion "spaces do not simply exist but are created in (generally repetitive) social action, and that, as spatial structures embedded in institutions, they guide action" (Löw, 2008, p. 40) is congruent with the concept of public spheres. We could imagine space as an element that impacts public conversation and evolves as a property of public imaginations surrounding any topic. In this way, public spaces/places and issues are co-created and spatiality is defined as a communicatively constructed dimension of any issue (Stoltenberg, 2021). The growing prominence of digital media in general, and particularly social media, has called into question how space descriptions apply to new digital public spheres (Benkler, 2006; Schäfer, 2016), leading to a description of space inscribed in digital public spheres in three ways: through the spatiality of actors, networks, and content (Pfetsch et al., 2019).

Issue spatiality is understood as a macro-level characteristic of public issue discourses (Waldherr, 2017, p. 544), manifesting at the output level of these discourses (Gerhards & Neidhardt, 1991, pp. 34-35). It arises specifically through the use of place names in public communication, known as place-naming (Gutsche, 2014; Stoltenberg, 2021; Wiard & Pereira, 2019). Place-naming refers to the act of publicly referencing specific locations in various contexts, and it represents an empirically observable social practice that fundamentally shapes and drives the concept of issue spatiality. Through repeated acts of place-naming by many different actors over time, spatial patterns become visible. The understanding of issue spatiality as a macro-level property highlights that no individual piece of public communication (be it a news article, statement by a politician, or tweet) creates an issue space. Instead, the repeated invocation of specific places in relation to issues by a heterogeneous set of actors gives room for a public issue.

Within issue discourses, place-naming works in conjunction with a variety of other message features, such as the discussion of particular sub-issues, use of communicative styles, or discursive connections to other places, to create specific contexts in which places are relevant (Stoltenberg, 2021).

With the advent of digital technologies, entrance barriers to public discourses have dropped, allowing for a broader diversity of speakers (Waldherr, Klinger, & Pfetsch, 2021), allowing actors to unite around shared issues and seek for their definition (Bennett et al., 2015, p. 109). The rising organizing of public spheres into 'issue publics' reignites the debate over how issues are formed in public discourse. In the context of digital communication, with its expanded and more varied actor set, diversity of views, and setting up into networked "issue publics" (Bennett et al., 2015), public communication spaces have gotten minimal attention. As highlighted by Stoltenberg (2024), the places included in the content of digital public communication are particularly understudied.

On social media, where diverse actors form issue publics, place-naming can be practiced both by actors who are located in a particular place and by actors who are not. Stoltenberg (2021) refers to

these types as resident and nonresident communication, and understands issue spatiality as an amalgam of both. While (local) communities use social media to organize and create visibility for themselves (Jackson & Foucault Welles, 2015), this does not remove outside voices from the debate. Journalists and media, political actors, and private individuals who reside elsewhere will routinely engage in communication about places. Unless individual speakers explicitly disclose their location, it will not be possible for the audience to separate the two. Moreover, there are intermediate forms, which are conceptually neither fully resident nor nonresident communication. For instance, residents may share mass media coverage of their neighborhood on their personal social media accounts.

In digital public spheres, a diverse range of individuals, each with their own motivations and beliefs (Waldherr, Klinger, & Pfetsch, 2021), contribute to discourse development into multiple sub-issues and opposing viewpoints which comprise an emphasis on personal narratives that are occasionally linked together into activist frameworks (Bennett & Segerberg, 2012, p.2). One area of concern for scholars in addressing the public debate on social media is the "information problem," which Born and Edgington (2017) identify as consisting of three interrelated issues: misinformation, disinformation, and online propaganda. The distinction between disinformation and misinformation primarily lies in the intent behind the false information. Disinformation refers to intentionally misleading or false information spread with the purpose of deceiving (Shu et al., 2020), while misinformation involves incorrect or misleading information (Fetzer, 2004) that is shared unintentionally, often seen as an "honest mistake" (Shu et al., 2020). Users may spread misinformation due to trust in sources like family, friends, colleagues, or social media influencers. The intent, in this case, is usually to inform rather than deceive. Online propaganda, however, involves presenting information that may be factually accurate but is framed to disparage opposing views (Tucker et al., 2017). Its primary aim is not just to inform but to garner public support (Born & Edgington, 2017). Online propaganda is often politically charged, appearing in the form of hyper-partisan news, which promotes a political party or its members while criticizing or blaming opponents. A central objective of online propaganda is to ensure that certain media stories gain more visibility than others (Sanovich et al., 2018).

The goal of this article is to analyze the debate concerning radioactive waste, fueled by the National Depository controversy that disrupted the public opinion potentially creating socio-political conflicts able to influence governance policies (Tucker et al., 2018). The research questions we aim to answer are the following:

1. Which actors shaped the network that contributed to the spatialization of the National Radioactive Waste Depository issue? Can some of them be described as disinformative actors?
2. What spaces and places are part of the public issues debated in relation to the radioactive waste controversy?

The spatialization of the main actors and their network returns an heterogeneous mapping of the media ecosystem that took part in the debate, highlighting networks of regional-dimension that have been renamed NIMYR (Not In My Region) communities. The spatialization of the issue frames a debate that on the one hand transcends national boundaries by reenacting episodes distant in space (Chernobyl and Fukushima) and on the other hand expands the temporal horizon by evoking episodes from the historical memory of users (Scanzano Jonico 2003). The visual content analysis

helps to paint further nuances of the colorful debate under the lens, and the qualitative content analysis underlined hyper-partisan propaganda occasionally spreading disinformation. The paper exposes the potential political implications of such a complex and unregulated ecosystem, highlighting the importance of well-structured communication strategies to avoid gridlock or public conflict.

2. METHODOLOGY

Digital phenomena pose unique challenges to social science researchers studying the impact of new and evolving technologies. These challenges are represented by the nature of the site of inquiry, the digital medium, crossing geographic boundaries and spatial divisions, social structures of hierarchy and power, national and political boundaries, and educational divisions, which are most evident in physical spaces (Kaur-Gill and Dutta, 2017). The research relies on Digital Methods (Marres, 2015; Rogers, 2019) to collect and process data from two Social Media platforms (X and Facebook). Digital methods are research strategies that analyze natively digital data from web platforms to represent collective phenomena, social changes, and cultural expressions. In this contribution we focus the attention on social media data containing geographic information in the form of place-naming (Gutsche, 2014; Wiard & Pereira, 2019), with the purpose to spatialize the phenomenon under study (Stoltenberg, 2021; McKitrick, Schuurman, & Crooks, 2023), by merging Natural Language Processing (NLP) to extract location information and Social Network Analysis (SNA) to map the extracted information. The research design also involves qualitative content analysis and image analysis aimed at gathering additional details to help contextualize the quantitative analysis and add some nuances at the debate.

2.1 Data Collection

Data collection consists in two sequential steps, the first one consists in the definition of the query design that selects the keywords and their combination to later collect (through Twitter's API or Meta's dashboards) reliable and consistent data to analyze. In our case, we defined two queries, one containing keywords referring to nuclear/atomic energy and radioactivity (Q1) and the second referring to waste and deposit (Q2). The final query (Q_f) will be the intersection of the previous ones, which allows to strictly select the subtopic "waste deposit" debated in the context of "nuclear and radioactivity". The time period defined comprehends the first 6 months of 2021, which has been considered sufficient to capture the bulk portion of the social media debate that broke out in early January 2021.

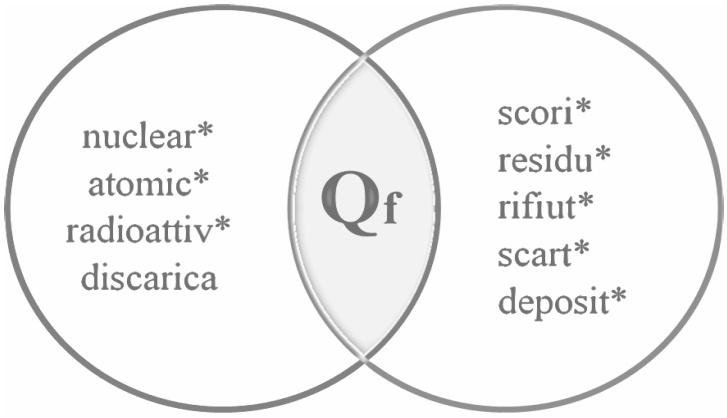


Figure 1. The figure sums-up the query design for the research where Qf is the intersection between the queries Q1= nuclear OR atomic* OR radioattiv* OR discarica and Q2= scori* OR residu* OR rifiut* OR scart* OR deposit**

The second step consists in capturing data. To collect data from Twitter, we relied upon 4CAT (Peeters & Hagen, 2022) using Twitter's APIs for Academic research. Differently, to collect data from Facebook, we used Crowdtangle (2022). The first difference is that Twitter allows data collection from every user, while Meta only gives access to the public content from verified accounts, public pages, and public groups. We have been able to collect 10'847 Facebook posts and 12'669 tweets. Both datasets have been uploaded to 4CAT for the SNA and to CorText (Breucker et al., 2016) for the NLP phase that will be explained below.

2.2 Natural Language Processing & Machine Learning

The NLP will be used to extract both locations and peculiar terms of the debate from the posts text body. The location identification relies on Machine Learning, with Convolutional Neural Network from the SpaCy library that will execute a Named Entity Recognizer task able to recognize countries, cities, states and other spatial references. The algorithm works as a black box, but we know has been trained with news and media for the Italian language.

The peculiar terms will be extracted with a Terms Extraction task that relies on NLTK (Natural Language ToolKit). The text body is preprocessed in three phases: Part-Of-Speech tagging, chunking and stemming. The Part Of Speech tagging tool categorizes terms based on their grammatical category, such as noun, adjective, verb, or adverb. During the Chunking phase, tags are used to identify noun phrases in the corpus; a noun phrase is defined as a sequence of nouns and adjectives. This stage creates the set of possible multi-terms. The stemming phase is dedicated to manage multiple terms that can be grouped together if they have the same stem. For example, singular and plurals are automatically placed into the same class (for example, "municipality" and "municipalities" are two possible forms of the stem "municipalit-"). Snowball stemmers are used for French, German, and Italian (Bird, Klein & Loper, 2009). The most relevant terms are chosen based on a balance of specificity and frequency. By default, specificity is calculated as a chi2 score (sum of all terms). It is also conceivable to utilize a simpler G2 score (gf.idf for Global Frequency/Inverse

Document Frequency derived from the well-known Term Frequency/Inverse Document Frequency TF-IDF).

Stem	Main form	Forms	n	C-value	Gfidf	Specificity chi2	Occurrences	Cooccurrences
depos nazional rif	Deposito Nazionale dei rifiuti	Deposito Nazionale dei rifiuti|&|Deposito nazionale rifiuti|&|deposito nazionale rifiuti|&|Deposito Nazionale di rifiuti|&|Deposito Nazionale per rifiuti|&|rifiuti al Deposito Nazionale	4	170,77	1,05	4546,50	82	372
rif sit stoccagg	siti di stoccaggio dei rifiuti	siti di stoccaggio dei rifiuti|&|sito di stoccaggio dei rifiuti|&|siti di stoccaggio di rifiuti|&|sito di stoccaggio rifiuti	5	49,64	1,00	4890,95	25	101
costruzion depos	costruzione del deposito	costruzione del deposito|&|costruzione del Deposito|&|costruzione di deposito	3	212,44	1,05	3857,34	129	481
dell'ent nazional parc president	presidente dell'Ente Parco Nazionale	presidente dell'Ente Parco Nazionale	4	33,76	1,00	4047,30	17	209
fungai mini-central	fungaia di mini-centrali	fungaia di mini-centrali	3	61,37	1,00	8427,10	39	1111
central ex scor	scorie delle ex centrali	scorie delle ex centrali	4	35,74	1,00	1955,26	18	748
infrazion procedur	procedura di infrazione	procedura di infrazione	3	39,34	1,00	1987,91	25	137
discussion fort	forte discussione	forte discussione	2	50,36	1,00	4451,22	32	984
di radioatt scor	DI SCORIE RADIOATTIVE	DI SCORIE RADIOATTIVE|&|SCORIE RADIOATTIVE DI	3	41,70	1,00	2657,11	21	147
depos nazional scor	Deposito nazionale scorie	Deposito nazionale scorie|&|DEPOSITO NAZIONALE SCORIE|&|Deposito Nazionale delle scorie|&|Deposito Nazionale di scorie	3	79,43	1,11	2748,99	36	132

Table 1. Example results of particular terms extraction.

Both locations and peculiar terms will be indexed in the dataset, allowing us to compute a bipartite graph that shows the relations between the most prominent terms that describe the issues and the locations extracted that will allow us to spatialise them using SNA as described in the following paragraph.

2.3 Social Network Analysis

The SNA will be performed using the dedicated software Gephi (Bastian, Heymann, & Jacomy, 2009) in order to map the Actors spatiality and the Issue spatiality. Regarding the Actors' spatiality and their network, we will follow the principles of the Actor-Network Theory (Latour, 2007) including in the actor definition both human agents (users, pages, groups) than non-human entities (newspapers, websites or platforms). This choice is due to social networking sites including the feature of hyperlinking, with references to material on different social media networks and online spaces constituting a common dynamic. The deliberate use of this resource (Ryfe et al., 2016) shapes networks (Fu & Shumate, 2017) and creates an integrated media landscape (Singer, 2019) that impacts how people discover, absorb, and disseminate news (Martin & Dwyer, 2019). Users inside this ecosystem can select the preferred option to meet their communicative goals, creating a customized social media ecology (Bayer, Triệu, & Ellison, 2020).
To map the spatiality of actors and their network, our main hypothesis is that actors (users, groups, pages, news sites, newspapers) containing a clear topological reference can be spatialized in those same geographic coordinates (Samuel & Sharma, 2021). In that way, considering both usernames and web domains we will shape a network of information dissemination exploiting "*people's references to locations that represent momentary social hotspots*" (Stefanidis, Crooks, & Radzikowski, 2013) to derive the spatial characteristics of the entire network. The actor graph traces the relationships between different actors that appear in the same post/content, spatializing those

that contain geographic names and applying a ForceAtlas algorithm to infer the locations of other actors and the network's flow.

In order to map the most debated issues, an additional bipartite graph has been produced to trace the relationships between the places extracted with the Named Entity Recognizer algorithm and the peculiar terms extracted with Natural Language ToolKit. In the following step, the places are spatialized, fixing their location on the map, while the themes are spatialized using the selected ForceAtlas algorithm. Since the extracted places have different dimensional scales (from continent to small towns), we opted for a trade-off of accuracy at the regional level. This means that larger entities are spatialised outside the Italian map, while small cities will be spatialized in their home region, paying attention to map readability.

Applying an ordering algorithm called Force Atlas we shape the connections highlighting main clusters, communities and relevant nodes. The Force Atlas algorithm is a force directed algorithm that has been chosen for its focus on quality, meaning "being useful to explore real data", and a good readability, to allow a rigorous interpretation of the graph with the fewest biases possible.

2.4 Qualitative content analysis

In order to grasp further nuances of the debate, the analysis also included a qualitative content exploration aimed at depicting the typology of users (politicians, activists, journalists or common people), the different declinations of the topic under discussion and eventually the stance regarding the National Radioactive Waste Depository. We sampled the total database (containing 23'516 items), extracting 422 items in order to achieve a 95% confidence level with a 4.75% margin of error.

From our X dataset we also extracted 1'466 images that we analytically displayed using the free software ImageSorter. The idea is to exploit a peculiarity of the platform which is the frequent presence of images that can be grouped through arrangements collectively referred to as metapictures (Rogers, 2021). The goal of this parallel approach is threefold:

1. To explore the output of the images in search of objects, people, places, or events, in order to better understand what the posts are about and how they relate to trends or themes.
2. To recognize the social or geographic context of the images, such as specific events or environments.
3. To analyze the symbols and visual codes in the images, aiming to understand the implicit messages, cultural connotations, and reference values they convey.

2.5 Ethic Guidelines

The research took into consideration the ethical dimension to more adequately address the issues of anonymization, pseudonymization and data minimization, grasping the policies of the University following the "public good principle." In light of the above considerations, we opted for practical

operations on the document, such as blurring images with clearly visible faces, avoiding citing private profiles by presenting only aggregate data, clearly distinguishing public figures with in-text citations, and citing channels that do not contain private personal information.

3. RESULTS

3.1 Actors & Network Spatiality

The map below (Figure 2) has the main intention of supplying an answer to our first research question concerning Actors and Network spatial dynamics. It maps the ecosystem by showing the relationships between the main actors: social media users but also groups, pages and external platforms, websites and news-media, that interacting online create an interconnected information flow.

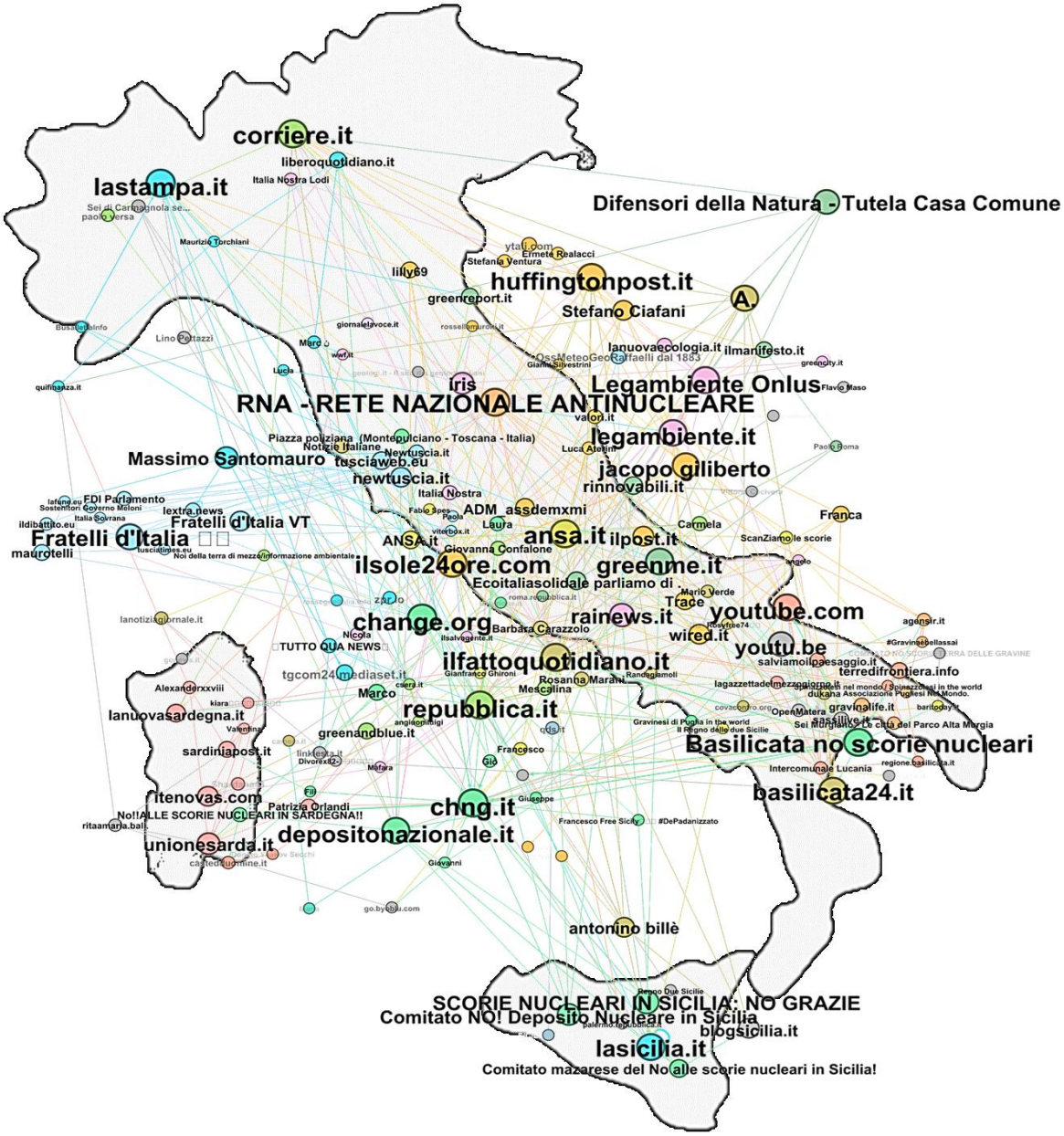


Figure 2. The user spatiality and the network elaborated with Gephi and overlaid on the Italian map.

We noticed the prevalence (as expected) of National media outlets as main sources of information (Repubblica, laStampa, Corriere, Il Fatto Quotidiano) together with a significant amount of local media outlets (laNuovaSardegna, Basilicata24, Tusciaweb, laSicilia).

The domain chng.it refers to a platform dedicated to online petitions, which is spatialized among southern regions, due to the close connection with users/pages that have mostly shared petitions using the platform for active antagonism to the national depository. These pages have regional dimensions and could be labeled as Nimby regional movements since the page name is usually "No to Radioactive Waste Depository in [insert Region]". The acronym Nimby (English for "Not In My Back Yard") denotes the protest by members of a local community against the construction of public works with major impacts (e.g., major thoroughfares, quarries, settlement or industrial developments, waste-to-energy plants, landfills, hazardous substance storage facilities, power plants, and similar) in an area that is perceived by them as close to their daily interests, but that they would not oppose the construction of such works if in another location less important to them. The expression dates back to the 1980s and is attributed to W. Rodger of the American Nuclear Society. It is linked to British politician Nicholas Ridley of the Conservative Party, then Secretary of State for the Environment (De Luca, 2012). In our case these instances could be renamed with the acronym NIMYR (Not In My Region).

Among the other main actors we can see "RNA – Rete Nazionale Antinucleare" (translated as Antinuclear National Network), a page with 40K followers which shows the convergence in the debate of actors involved in activism against nuclear energy for civil purposes.

Other major nodes are connected to Legambiente, an Italian environmental association that is heir to the early ecological nuclei and the antinuclear movement that developed in Italy from mid 1970s. The actors are mainly located in the center and tied to Lazio actors. The reason might be the countercultural leadership of Legambiente Lazio, which has been open to dialogue about the National Depository , compared to the position of the other regional divisions, which have strongly advocated against it (Alaimo, 2023).

Some communities revolve around specific political parties, and particularly in Lazio we can identify different social media pages of the right wing party Fratelli D'Italia that configures as one of the main actors of the debate in the region.

Another main node of the debate is Youtube, which is positioned on the southern part of the map strongly connected to Puglia and Basilicata actors. Youtube is a key node that deserves further attention since its increasing dominance as a key actor of nowadays online information ecosystem (Soriano & Gaw, 2022).

3.2 Issue Spatiality

The image below (Figure 3) has the main purpose of providing an answer to our second research question, showing the Issue spatiality by mapping the places (extracted through NER) with the peculiar terms of the debate (extracted through NLTK). The analysis shows several thematic clusters that have mainly a regional dimension, but we can see the spatiality of the debate crossing national borders. This analysis has been implemented using only Facebook data which, allowing for longer

posts than X/Twitter, results in more structured text that better performed in the peculiar terms extraction task.

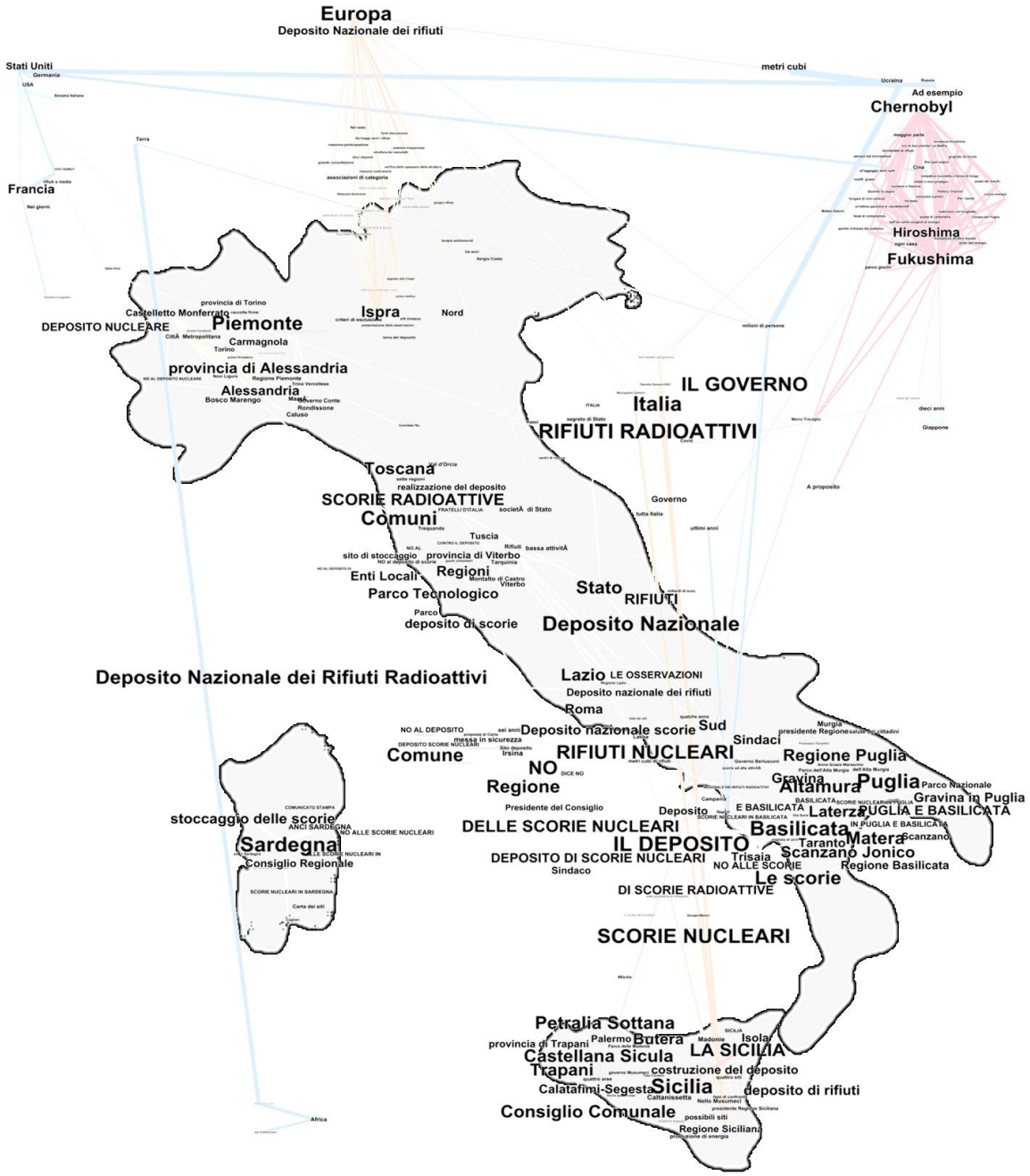


Figure 3. The Issue spatiality elaborated with Facebook data analysis. The place-issue graph is elaborated with Gephi and overlaid on the Italy map.

The main keywords are relative to the National Depository itself, with references to radioactive waste and nuclear waste. All the regions show clear messages against the National Depository, depicting highly extreme positions on the subject. Each region presents some peculiarity, in Sicily we can identify references to the Region President Nello Musumeci, underlining the political nature of the debate. The peculiarity of the debate in Puglia and Basilicata is the presence of references to the episode of Scanzano Jonico (Scanzano and Berlusconi Government) and to the National Park (Alta Murgia) in whose proximity a number of potential sites have been identified, underlining a

particular attention to natural heritage sites. Moving the focus to the central cluster we can identify other narratives related to two nuclear sites: the closed nuclear power plant in Latina (which is currently a temporary radioactive waste depository), and the failed project of the nuclear power plant in Montalto di Castro, at the border between the regions Lazio and Tuscany. Peculiar keywords in this case are “securing”, “cube meters of waste”, “low activity” with respect to the Latina temporary waste depository.

Another thematic cluster revolves around the locations of Europe and Ispra. Europe is intended as a reference for the European Union, while Ispra has a dual meaning. Ispra is a municipality in Varese province where the Joint Research Center (JRC) headquarters are located. The JRC is a European Commission research center made up of scientific institutes that provides independent support in shaping the European Union's energy and environmental policies. Ispra is also the acronym for “Istituto Superiore per la Protezione e la Ricerca Ambientale” (Superior Institute for Environmental Protection and Research) which is the agency in charge for defining the criteria adopted to draft the CNAPI. Our content was mainly referred to this second institute, with keywords such as “exclusion criteria”, “structural check”, “large consultation”, “category association”, “waste from ex nuclear plant”, “extreme transparency”, “Unesco sites” and “fake news diffusion”. All those terms are related to nuances of the informational process that shapes public opinion and are all fundamental aspects to correctly vehiculate the information to the population.

Finally, another thematic cluster orbits around the three locations that most prominently evoke (in a negative way) the collective imagination inherent in nuclear power: Hiroshima, Chernobyl, Fukushima. Here the discourse on the one hand seems to be concerned given the prominence of the terms and the presence of secondary terms such as “transition to the other world” and “cancer deaths”, on the other hand the discourse seems to be approached with irony, with terms such as "aerosol from the mini-reactor," fabulous grilling" and "cute little mushroom cloud".

3.3 Qualitative insights

The image below (Figure 4) is a graphic elaboration in which the images are sorted by color similarity. The goal is to analyze the visual dimension of our data by exploring the content that characterizes the debate under consideration and expresses a certain degree of spatiality. In this case, spatiality is not only intended as a specific coordinate or location but envelops in a broader sense any element that may contain references or even abstractly represent places, spaces, people, events and symbols that can be traced back to specific social spaces.

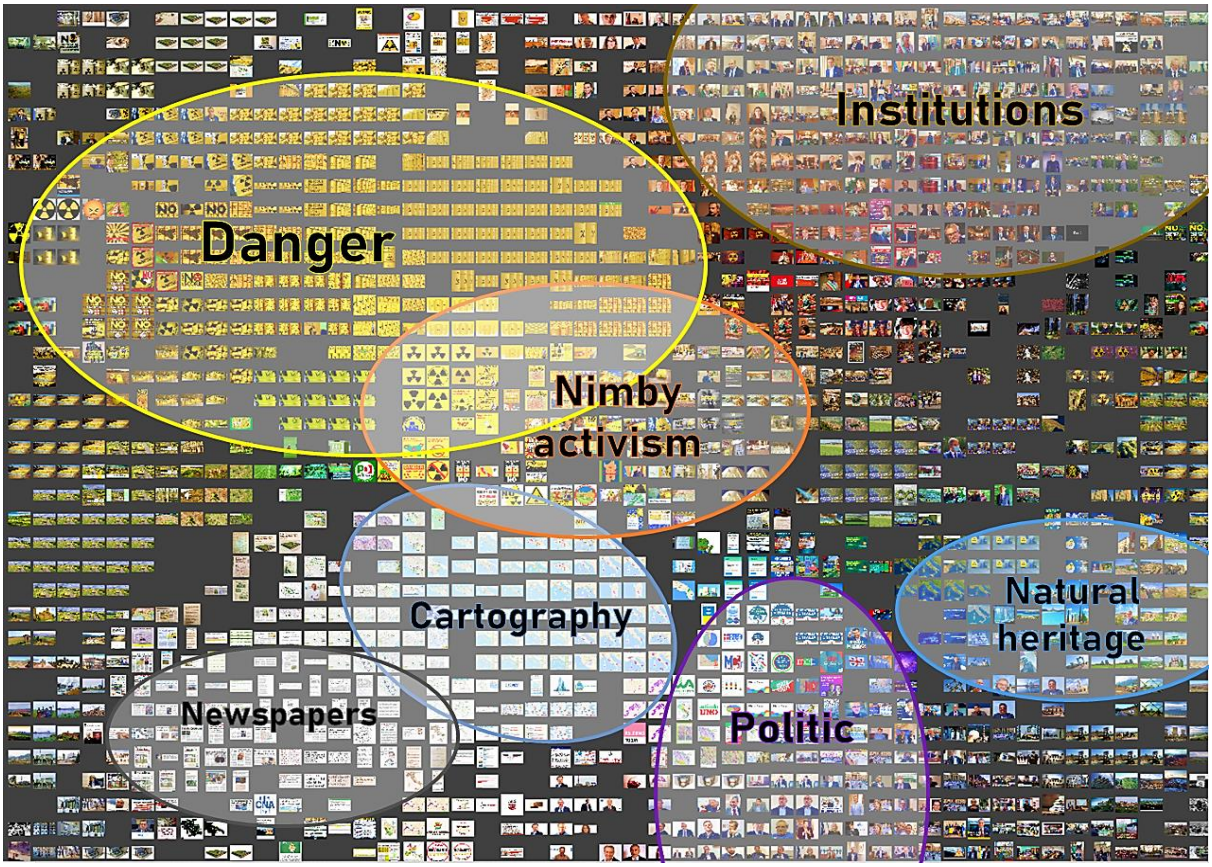


Figure 4. Imagesorter output which shows a visual media analysis to highlight some aspects of spatiality representations.

The first aspect that catches the eye is the presence of a large yellow cluster with radioactive danger symbols. The symbol communicates alertness and may also convey a sense of proximity (temporal or spatial) to the source of the potential danger. Near the yellow cluster we find the orange one which is partially overlaid and refers to the NIMBY activism. In this case the space narrated is the streets, the squares and generally the places of protest. The Institutions cluster returns a picture of the institutional spaces in which the debate takes place, such as municipalities and council chambers representing from small towns to large cities. The Cartography cluster describes with different regional or national maps the spatiality of the potential sites and the relations of those places with other sites such as urban areas or national parks. The natural heritage cluster shows places such as monumental sites, UNESCO sites or natural parks of undoubted landscape interest that could be affected by the presence of a waste depository. Finally, the other main clusters, related to political parties and newspapers, do not primarily describe spatiality aspects.

The qualitative content analysis served a double purpose: on the one hand helped to better contextualize the dynamics observed with the social network analysis, on the other hand revealed several hyper-partisan channels devoted to propaganda and others that conveyed misinformation and disinformation. Especially in the first weeks there was misinformation about the number of depositories to be built and their precise location. Several channels/users erroneously shared the news reporting the construction of depositories in 7 Italian regions, or as many as 67 separate

depositories, going so far as to specify completely false details such as the construction of "3/4 depositories for each region."

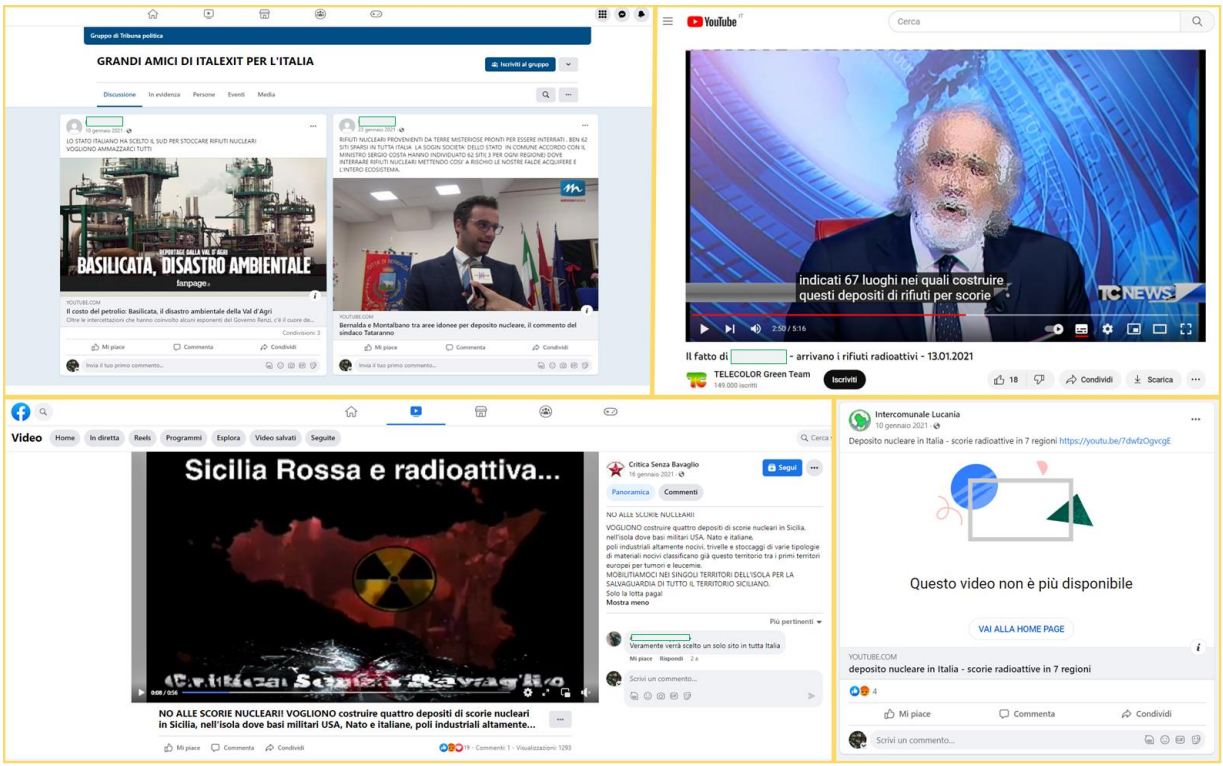


Figure 5. The image shows examples of content that vehiculated wrong or misleading information regarding the National Radioactive Waste Depository.

Other content used alarming tones and deliberately inaccurate words to raise the level of user outrage. There has been superficial talk of "waste burial," terminology that while technically correct (the waste will actually be placed below ground level) harkens back to an imagery of illicit actions in waste management. The alt-news channels reported that the National Depository will house nuclear waste from northern Europe or "mysterious lands," an inaccuracy probably stemming from the news that some of the "Italian" waste, currently stored in France and the UK, will return to Italy to be placed in the National Depository. There has been talk in alarmist tones of risk to groundwater and the entire ecosystem even going so far as to accuse the Italian state of "wanting to kill everyone." Much of these inferences come from a Facebook group revolving around the populist and Eurosceptic political party Italexit, which in the last parliamentary elections garnered approximately 500,000 preferences but failed to win any seats. The pages of other political parties have also participated in the misinformation and created confusion by addressing the depository as a "nuclear fuel depository," as in the case of the La Lega party through its official page for the Chamber of Deputies.

4. DISCUSSION

Actors&Network spatiality and Issue spatiality helped to shape the dynamics of the debate and, along with qualitative content analysis, highlighted specific sub-issues and positions in the debate, providing multifaceted knowledge.

The research shows a complex debate involving many different actors: activists and associations (LiberiOltre, Legambiente, Rete Nazionale Antinucleare, Change.org); companies (SoginChannel, ISPRA); mainstream news outlets (Repubblica, Corriere, ilSole24Ore, HuffingtonPost); local news outlets (TG Antudo, TRM Network); alternative-news channels (CasaDelSoleTV); national and regional politicians (Nello Musumeci, Rosa D'Amato, Eugenio Zoffili); municipalities (Torino, Carmagnola, Altamura, Melpignano, Paulilatino); and mayors of local governments (Paolo Truzzu, Michele Emiliano, Gianluca Colletti); as well as ordinary citizens. The debate usually starts in public groups and pages on Facebook or X threads characterized by the use of toponyms. Those digital spaces can be labeled as "glocal" (Roudometof, 2023): shaped to accommodate local publics but able to potentially create long-distance interactions. The claims expressed in those digital spaces are mostly hyper-partisan positions dedicated to propaganda that occasionally results in disinformation and misinformation.

Positions in favor of the National Depository come mainly from activists (AvvocatoAtomico, LiberiOltre) and the company Sogin that is in charge of the project. The motivations in supporting this position are the need to align with other European countries by emphasizing the need for a safe and modern depository for storing radioactive waste of different intensity (low, medium, and high). Neutral positions are typical of informative channels (Geopop) but there is also the presence of positions open to debate by some politicians (Manfredi Potenti, Jessica Costanzo, and Lega Camera) who timidly call for participation of all parties involved in the decision-making process (Politics, territorial institutions, and citizens).

However, the prevalent narrative is against the realization of the National Depository, in a position that according to the literature (Bortoletti, 2004; Mura & Strazzera, 2013) can be labeled as NIMBY (Not In My Back Yard). The positions against the National Depository come almost entirely from local news channels/television/newspapers, alternative-news channels and politicians (regional and provincial presidents and municipal mayors). Italy is one of the European countries most affected by the NIMBY phenomenon, since 2004 an observatory on the NIMBY syndrome has been active, coordinated by a non-profit organization, with the cooperation from the Presidency of the Council of Ministers[2]. The observatory's purpose is to analyze the syndrome and collect data from mass media, internet and institutions. Currently 355 disputed public works are under the observatory's surveillance; among them 62.5% belong to the energy sector, followed by waste treatment plants (25.9%) and infrastructure facilities (8.7%). Data indicate that and main reasons for the protests include the impact on the environment (39.0%), on health (13.6%) and on quality of life (11.7%) (Buffoli, Odone, Leask, & Signorelli, 2016).

Relatively to radioactive waste, the debated issues show a lack of trust in the project pipeline and in the technologies involved, which merges with health and wealth concerns. The health concerns narrative is related to the fear of the radioactivity, in particular fear about water and air

[2] NIMBY Forum. Available at http://www.nimbyforum.it

contamination potentially coming from the depository but also in relation to the transport of such materials. The wealth concerns narrative is related to the fear of the potential negative effects on the local productive fabric, especially in territories where there is the presence of strategically important products (Controlled Designation of Origin or Protected Designation of Origin) but also Unesco World Heritage Sites.

Those claims also underline people recognizing and defending what is valuable of their own territory, emphasizing a prevalent local and regional dimensionality of the issues. Even if people are moved by self-serving ends, this underlines the importance to distinguish between good and bad NIMBY claims (Feldman & Turner, 2014). The easy attribution of anti-project labels can disqualify any valid arguments brought against the project, such as criticisms of various aspects of the plan, from environmental impacts to assessments of its actual usefulness to comments about the economic interests supporting it. Thus, the NIMBY argument lends itself to being used speciously by both those who support the project ("all opposition is caused by the NIMBY syndrome") and those who oppose it ("our arguments are not being heard, they claim it is just a NIMBY protest").

The Issue spatiality shows different political actors (regions, regional presidents, regional councils, provinces, municipalities, municipal councils and mayors) that mostly assume NIMTOO (Not In My Terms Of Office) positions, acronym used to identify the protest with a political connotation to attack opponents (Tipaldo, 2015). In this situation the political attack is vertical, meaning that local and regional institutions usually attack upper institutions such as past and present National governments. The Issue spatiality mapped on Figure 3 evidences a specific dimension of the NIMBY phenomenon, which is the regional one, leading to the coining of the acronym NIMYR (Not In MY Region). NIMYR positions are characterized by the convergence of NIMBY claims by ordinary citizens and NIMTOO claims by political actors, intending the Region as both a geographical and institutional entity.

The qualitative content analysis also let the secular North-South Italy dichotomy emerge. Different social media users expose their views with slogans to emphasize how the south has “other serious problems” and should not be used as a "national dumping ground." In this regard two past episodes are often cited:

- The “Land of fires” (Terra dei fuochi), in Campania, a region not affected by the Cnapi, in relation to the burial of toxic and special waste, the presence of numerous illegal dumping sites scattered throughout the territory, and the ignition of numerous waste fires, which spread dioxin and other polluting gasses into the atmosphere (Peluso, 2015);
- The episode of Scanzano Jonico (Basilicata) dates back to November 2003, when only local protests succeeded in blocking the plan for a National Radioactive Waste Depository unilaterally desired by the Berlusconi government (Zinn, 2017).

Those narratives appear to be present in the collective consciousness of the Anti-Depository positions and are evoked through Youtube Videos showing documentaries, TV newscasts and videos from the past. The spatialization of the issue returns a mapping that on the one hand confirms the fragmentation of the debate at the regional level and on the other transcends spatio-temporal boundaries by evoking episodes far away in space and/or time (Chernobyl, Fukushima, Scanzano Jonico 2003 and even Hiroshima). The analysis of the images returns a picture that represents the different spaces of debate: institutional spaces such as council chambers, geographic spaces such

as green areas affected by CNAPI, and public spaces that have become the site of political demonstrations.

The qualitative content analysis highlighted several aspects related to problematic information such as hyper-partisan channels devoted to propaganda and others that conveyed misinformation and disinformation. The radioactive waste debate revolving around the National Depository controversy suddenly disrupted the public debate and developed in chaotic directions leading to the formation of opinions based more on emotions, biases, and distorted perceptions than on informed discourse. The risk of distorted information that feeds public opinion increases significantly without a well-planned political communication strategy (Goldstein et al., 2020), allowing the topic to potentially evolve toward extreme polarization, causing socio-political conflict that can lead to a decision-making stalemate.

For public projects of this magnitude, especially those involving sensitive issues like radioactive waste, effective communication is essential. A well-structured communication must include a trusted network of experts and collaborators, facilitate the validation of online information, provide access to data visualizations with diverse granularity, and increase explainability of flagged disinformative content (Kyza et al., 2020). This approach should help prevent the topic from suddenly becoming the subject of heated debate, reducing the risks of escalating social conflict and disinformation.

5. CONCLUSIONS

This social media research has shed the lights on the Italian radioactive waste debate, which emerged with the controversy over the National Radioactive Waste Depository. The research has some intrinsic limitations due to the spatial analysis of social media data, which can be limited by linguistic ambiguities, geographic biases and non-representativeness of users. Toponyms, often found in posts, may have local variants, dialects, or abbreviations that complicate their identification when using automated data mining methods. In addition, social media does not uniformly reflect all areas of the country, with rural or less digitally connected regions often underrepresented. A technical limitation of this study is that Facebook content is extracted only from public pages, public groups, and verified profiles due to Meta's policies on privacy. However, it should be underlined that content shared in Facebook public groups and pages usually comes from profiles belonging to everyday users, mitigating the limitation and allowing us to have a partial representation of this type of users. Active users are not always representative of the general population: youth, activists or groups with specific political beliefs dominate the discussion, leaving other segments of society underrepresented.

However, this research showed the potential of a quanti-qualitative approach that leverages different computational techniques by merging digital methodologies such as Natural Language Processing and Social Network Analysis. The spatialization of the actors and their network painted a detailed map of the social media information ecosystem, enhanced by the issue spatialization of the debate that allowed for a more articulated description of the controversy. In particular, this research has highlighted how fear of radioactive waste and/or opposition to the National

Radioactive Waste Depository comes from both ordinary citizens and local institutions, converging in a position that has been renamed NIMYR (Not In MY Region). The whole picture has been enriched by insights coming from visual image analysis and qualitative content analysis, in a multidisciplinary approach that shows promising avenues to explore complex social phenomena.

In conclusion, this research highlights the evolution and fragmentation of radioactive waste-related breaking-news within the social media ecosystem, the consequences of which can have an impact in real life as it embraces issues of fundamental importance to today's society, such as politics, environmental sustainability, and the economy. The importance of political communication is crucial when it comes to public projects that touch on sensitive or controversial issues with a direct impact on large segments of the population. Positive attitudes toward nuclear waste repositories derive not merely from a perceived attention to benefits, but largely from a decreased perception of risks (Seidl et al., 2013). Without these communication efforts, the polarization of local communities can quickly exacerbate, leading to a stalemate in decision-making processes, as demonstrated by the strong opposition to the National Depository project.

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Navigating the Digital Battlefield:

Social Media, Disinformation, and Atomic Narratives in the Ukraine Conflict

Abstract

The conflict between Russia and Ukraine has quickly become a major geopolitical issue, with profound global consequences. At the same time, social media platforms have played a crucial role in shaping the information landscape of the conflict. The nuclear narrative emerged as a central theme, with power plants and nuclear escalation fueling public and expert debate. The digital battlefield has been characterized by disinformation and propaganda, contributing to the fragmentation of public opinion. The methodology relies on computational approaches to model the social media ecosystem, which is explored with qualitative content analysis. The goal is to highlight the role of social media platforms in shaping public debate and to frame them in light of the Digital Services Act, a recent regulation that aims to mitigate the systemic risks posed by the dissemination of information that can negatively impact civic discourse, while also protecting media freedom and pluralism.

Keywords: Social Media Ecosystem, Disinformation, Nuclear conflict, Ukraine-Russia, Digital Services Act;

INTRODUCTION

The tension escalation between Russia and Ukraine has been one of the thorniest and most sensitive geopolitical issues of the 21st century, with an armed conflict that has shaken Europe and had significant impacts on a global scale. At the heart of this crisis are the deep historical, geopolitical, and ethnic divisions that permeate the region (Harris, 2020; Giuliano, 2018). The Russian-Ukrainian war, which began in 2014 with Russia's annexation of Crimea and conflict in eastern Donbass, has caused immense suffering for both nations involved. On the one hand, Russia claims to be protecting the interests of ethnic Russians inside Ukraine and protecting its geopolitical interests in Crimea from Western countries. On the other hand, Ukraine defends its own sovereignty with the help of NATO countries who see Russian actions as a clear violation of the basic principles of international law. The conflict has resulted in thousands of deaths, millions of displaced people and continued instability in the region (Russo-Ukrainian War, 2024).

The term nuclear has been associated with the conflict chronicles in different ways. On the one hand, military operations have fueled the debate in relation to battles between the Ukrainian and Russian forces to control two nuclear facilities: Chernobyl (known for the accident that occurred on April 26, 1986) and Zaporizhzhya, the largest nuclear power plant on European soil. An aspect debated since the beginning of hostilities is how the perception of nuclear energy is shaped by the geopolitical situation of the Ukrainian conflict (Green, 2022). On the other hand, the terms "nuclear" and "atomic" have been employed to describe worst-case scenarios, positing the potential escalation of the conflict into a nuclear

confrontation. The narrative is fueled by the direct and indirect presence of the world's strongest nuclear powers, Russia on the one side and NATO countries (USA, UK and France among the others) supporting Ukraine on the other side. From a geopolitical and military perspective, political actors (Barel, 2022; Sethi, 2022) and the general public have different views on the possibility of atomic conflict (Riyadh, Drobov, Alkasaby et al., 2023), with some experts arguing that nuclear weapons possessed by both sides serve as a deterrent, while others argue for the effective possibility of using tactical nuclear weapons of "limited" destructive power. The public debate shows concern about the use of nuclear weapons, although the likelihood of a direct nuclear conflict is generally considered low, provocations continue to strain the stability of the region and increase international and public concern about an escalation that could lead to devastating consequences (Sethi, 2022).

From the very beginning, a peculiarity of the conflict has been its digital communication aspect, with information arriving directly from the front in real-time with no filter, and social media networks providing an essential and effective tool for the dissemination of information from both sides of the conflict. Social Media platforms became the digital battleground of the conflict, with a wide ecosystem of platforms permeated by issues such as disinformation, polarization, and algorithmicity, which can affect public perception and social stability (Barberá, 2020). This aspect falls within a dynamic called Information Warfare (Prier, 2020), in which, just as traditional warfare involves efforts to control territory and deny resources to the enemy, online conflicts revolve around controlling the flow of information in the social media ecosystem. The social media ecosystem is the complex and interrelated set of platforms, audience, content and dynamics that define the online social media environment. This ecosystem includes popular social networks, blogs, forums, video sharing platforms and instant messaging apps. These platforms serve as communication channels to connect individuals and communities around the world, where content can take many forms, including text, images, video, links and other media. These technological tools allow anyone to easily broadcast political information to large numbers of citizens, which can lead to a more pluralistic public debate, but they also risk giving space to extremist voices and actors who seek to manipulate the political agenda for personal, financial or political gain (Tucker et al. 2017).

The negative aspects can include tactics such as spreading disinformation or propaganda, manipulating algorithms to amplify certain narratives, or engaging in coordinated campaigns to discredit opponents. Partisan narratives and conspiracy theories have fueled hatred and division, underlining the difficulties for the parties involved to find common ground for reconciliation (Golovchenko, 2022), and letting digital platforms become virtual arenas for ideological clashes, with users who are split between supporters of Russia and Ukraine. State and non-state actors used fake accounts, automated bots, and propaganda websites to influence public opinion and manipulate the perception of facts (Pierri et al., 2023). Hyper-partisan disinformation on social media has fanned the flames of conflict, with the fragmentation and overload of information which makes it difficult to distinguish truth from propaganda. This digital environment contributes to fuel tensions between online and offline communities, amplifying existing divisions and undermining trust in traditional journalism and democratic institutions (Geissler et al., 2023). User dynamics, platform policies, and interaction with other sectors, such as journalism and politics, help shape the online environment, influencing opinions, behaviors, and social dynamics. The spread of disinformation and propaganda through social media makes the geopolitical situation even more complex to understand for the general public. In addition, the anonymous and decentralized nature of many social platforms makes it difficult to detect and counter disinformation in real time (Ahsan, Kumari and Sharma, 2019).

The online debate fueled by the war between Russia and Ukraine, and the different narratives (such as the Atomic escalation) in which the discourse evolves and is articulated, provides a significant case study to focus on the social media ecosystem with the purpose of improving our understanding of the role that different types of platforms are playing in the digital battlefield. Moreover, we have the opportunity to observe this online dynamic by projecting it in light of recent developments in terms of platform regulation, such as the European Commission's Digital Services Act (DSA) (2022). This unprecedented legislative initiative can be interpreted as an attempt by European institutions to limit the radical indifference (Zuboff, 2019) shown so far by online platforms. Shoshana Zuboff (2019) introduces the concept of radical indifference to refer to the regime of increased data availability on which Big Tech companies perform online behavior measurement while avoiding content moderation as much as possible. This approach results in ignoring the substance of the online experience, leaving room for the proliferation of low-quality content that fuels highly deleterious societal phenomena such as disinformation (Zuboff, 2022). With the aim to shed light on the disinformation dynamics inherent in the narrative of the atomic conflict, while also framing the multi-platform dynamics within the context of the recent Digital Services Act (DSA), the current research addresses the following research questions:

- How positions related to the atomic conflict narrative are articulated and disseminated across the social media ecosystem?
- Can peculiar platforms be distinctly associated with specific narratives or partisan perspectives?
- How do the observed disinformation dynamics fit into the framework implemented by DSA?

The research exploits a mixed quanti-qualitative approach using Digital Methods (Rogers, 2019) and other computational approaches such as Social Network Analysis (SNA) and Natural Language Processing (NLP) algorithms followed by qualitative content analysis. The quanti-qualitative analysis lets emerge how the nuclear and atomic narrative is declined in multiple directions which encompass political, historical, military, technological or energetic perspectives, emphasizing that the online debate is not homogeneous, but rather characterized by multiple narratives and perspectives influencing the digital information landscape. These pathways often stray from the original topic, sometimes finding a responsive environment within specific below-the-radar environments that are characterized by disinformation and hyper-partisan perspectives. These online social spaces need to be carefully considered as they risk limiting the positive effects put in place through international legislative initiatives such as the Digital Service Act (DSA). Addressing this challenge requires concerted efforts by the international community to promote transparency, truth, and accountability in online communications in order to mitigate the harmful effects of public manipulation and promote the information well-being of today's society.

METHODOLOGY

The research will use Digital Methods (Marres, 2015; Rogers, 2019) to gather and analyze data from two social media sites (X and Facebook). Digital methods are research methodologies that examine native digital data from online sources and repurpose it to

depict collective phenomena, societal changes, and cultural expressions. The methodological approach relies firstly on a phase of social network analysis (SNA) and natural language processing (NLP) followed by a phase of manual content analysis that deeply explores the insights. The elasticity of this approach is essential in exploring a highly dynamic environment such as social media.

The Hyperlink is the main digital object we will use as a feature present in all social networking platforms, where an ordinary dynamic is an ability to share links or references that lead to content on another social media network. The use of this resource is an intentional act (Ryfe et al., 2016) that creates networks (Fu and Shumate, 2017) and an interconnected media environment (Singer, 2019) that influence how users find, consume, and share news (Martin and Dwyer, 2019). The literature on cross-platform analysis has focused on standard hyperlinks considering news consumption (Park and Kaye, 2020; Del Vicario, Gaito, Quattrociocchi et al., 2017) or analyzed cross-platform dynamics among social media sites from the perspective of the user account (Amara, Hadj Taieb and Ben Aouicha, 2023; Gruzd, Lannigan and Quigley, 2018). Through their role in information dissemination, hyperlinks can make sense of social phenomena in their digital dimension due to their centrality in the digital environment (Hsu and Park, 2011).

The idea is to focus on social media content that contains hyperlinks to other social media platforms, in order to focus on content that (potentially) leads users to secondary social spaces. To distinguish them from intra-platform links, we will use the definition of Bridge. Bridge is a definition borrowed from transmedia theory to refer to an entity that connects different media in a transmedia universe and provides audiences with the motivation to cross them (Hayes, 2006). Bridge is thus a concept we can use to describe the connection between different social media platforms as a communication tactic enacted by users to expand their narrative space.

The textual content will be analyzed with Natural Language Processing applications and video/image content with manual content analysis. The data visualization will exploit Social Network Analysis (SNA) to elaborate the information coming from Natural Language Processing (NLP) and Manual content analysis in order to explore and grasp nuances of the debate.

Data Collection and Storage

The first step of data collection is to define a query design that considers the topic's nuances and details by determining the correct keywords and their combination to allow us to interrogate the database and collect reliable and consistent data to analyze. In our case, we defined two queries, one referring to nuclear/atomic conflict (Q1) and the second referring to the opposing sides of the Russia-Ukraine conflict (Q2). The final query (Qf) will be the intersection of the previous ones, which allows us to strictly select the “atomic/nuclear” narrative debated in the context of the “Russia-Ukraine conflict”.



Figure 1. The figure sums-up the query design for the research where Qf is the intersection between the queries Q1= nuclear* OR atomic* and Q2= Ukraine OR Russia OR Zelenski OR Putin OR NATO etc.

The second step consists in capturing data. To collect data from Twitter, we relied upon 4CAT (Peeters and Hagen, 2022) using Twitter's APIs for Academic research. Differently, to collect data from Facebook, we used Crowdtangle (2022). The first difference is that Twitter allows data collection from every user, while Meta only gives access to the public content from verified accounts, public pages, and public groups. This difference highly influences the dataset's dimension. We collected data both in Italian and English language, archiving a total of 93'303 bridges between platforms divided as follows: 2'112 italian posts on Facebook, 14'183 english posts on Facebook, 4'456 italian tweets and 72'552 english tweets. Both datasets will be uploaded to 4CAT for the SNA and to CorText (Breucker et al., 2016) for the NLP phase that will be explained below.

Social Network Analysis

The Social Network Analysis (SNA) will help to visualize the relations between different pairs of entities that will be extracted from the dataset. First goal is to visualize the map of the social media ecosystem. Starting from Facebook and X content, the first step consists in identifying the bridges (hyperlinks) towards other social media platforms, video sharing platforms and messaging applications. The bipartite graph will draw the relations between users and social media platforms domains that have been linked in the text, highlighting the connections that lead users toward secondary platforms. A second graph will show the relations between domains that have been shared (social media and also news-sites etc.) and keywords that will be extracted via Natural Language Processing (NLP) algorithms described in the following section. The extracted keywords identify specific subtopics with the aim to underline where (in which platforms) specific topics are going to be debated. The third step will take as input the qualitative analysis data by shaping a graph which shows relations between social media platforms and the main positions regarding the topics that have been observed and retrieved with qualitative content analysis.

The SNA will be carried out with the dedicated application Gephi (Bastian, Heymann and Jacomy, 2009). We shape the relationships employing an ordering algorithm called Force Atlas, which reveals important clusters, communities, and relevant actors. The Force Atlas algorithm, a force-directed algorithm, was chosen for its particular focus on quality (which is defined as "being useful to explore real data"), allowing for a rigorous interpretation of the graph with the fewest biases possible and good readability.

NLP Analysis

The NLP is aimed to extract the peculiar terms from the textual field of the posts from both Facebook and X in order to understand the main topics at the center of the debate. The text is elaborated with Cortext through a Terms Extraction task that relies on NLTK (Natural Language ToolKit). The text body is preprocessed in three phases: Part-Of-Speech tagging, chunking and stemming. The Part Of Speech tagging tool categorizes terms based on their grammatical category, such as noun, adjective, verb, or adverb. During the Chunking phase, tags are used to identify noun phrases in the corpus; a noun phrase is defined as a sequence of nouns and adjectives. This stage creates the set of possible multi-terms. The stemming phase is dedicated to manage multiple terms that can be grouped together if they have the same stem. The most relevant terms are chosen based on a balance of specificity and frequency. By default, specificity is calculated as a chi2 score (sum of all terms).

The extracted terms are indexed in the dataset, allowing to compute a bipartite graph that shows the relations between the most prominent terms (which identify topics and subtopics) and the URLs domains (to identify social media, video sharing platforms, internet sites in general etc.) appearing in the same post.

Manual content Analysis

To perform the qualitative content analysis a distinction has been made among the datasets for language (English or Italian) and content source platform (Facebook or X). We sampled our four datasets (Table 1) with stratified and systematic sampling that takes samples proportionally over time and considering the destination platform as parameter to determine the intra-sample proportion. It means Youtube-oriented content, which is the largest layer, will be sampled accordingly to its relevance in the entire dataset. We sampled the datasets in order to achieve for all of them a 95% confidence level and 5% margin of error.

Language	*Platform*	*Total*	*Sampled*
	X	4.456	354
	Fb	2.112	326
	X	72.552	383
	Fb	14.183	375
		93.303	1.438

Table 1. Sample content

The sampled content has been manually analyzed in order to enrich data with additional information such as the type of account in the destination platform, the topic debated and the position when clearly defined. While identifying the main topic was a relatively easy task (even considering the fragmented debate), identifying the position on the topic has been more challenging. The classification had to consider different nuances of the debate, for example distinguishing between anti-Ukraine and pro-Russia positions, with the former describing a distance from Ukrainian policy, while the latter also expressing approval for Russia's actions. The same goes for the distinction between anti-NATO and

anti-U.S. positions, with the latter specifically targeting the U.S. government, or the distinction between pro-Ukraine and pro-Zelenski stances.

Another fundamental task was the identification of potentially biased information. Born and Edgington (2017) describe the 'information problem' as consisting of three interrelated issues:

- Disinformation, false information disseminated intentionally;
- Misinformation, false information that can be propagated unintentionally;
- Online propaganda, information packaged in such a way as to denigrate opposing viewpoints.

For the sake of simplicity, we use the term 'disinformation' as an umbrella term to refer to any information that can be encountered online and could lead to an incorrect worldview. The umbrella definition of disinformation also includes:

- Unverified information, sometimes known as rumors, which is information that has not been confirmed and may turn out to be untrue or erroneous (Wu et al., 2019);
- Hyper-partisan material which is news that attempts to represent a political party or its members favorably while ridiculing or condemning its opponents (Sanovich et al., 2018);
- Fake-news which are reports that are purposefully misleading in order to generate income or feed propaganda and become viral (Wu et al., 2019);
- Conspiracy theories which try to explain the origins of social and political events by alleging secret conspiracies between two or more powerful players (Douglas et al., 2019).

These categories have been used for classification, indexed in the data samples and will allow for the representation of relationships between specific platforms and disinformation content investigated during the qualitative analysis.

Ethic Guidelines

The study incorporated an ethical framework to more effectively address issues related to anonymization, pseudonymization, and data minimization, aligning with the University's policies grounded in the "public good principle." Based on these ethical considerations, we implemented practical measures on the documents, such as blurring images where faces were clearly identifiable, refraining from referencing private profiles by reporting only aggregated data, clearly identifying public figures through in-text citations, and citing sources that do not disclose private personal information.

RESULTS

The graph below shows a portion of the social media ecosystem we tracked by considering Facebook and X as starting points. The resulting graph is a User-Platform network, where the labels identify the different platforms and the nodes represent the users that shared a bridge directed to the specific secondary platform.

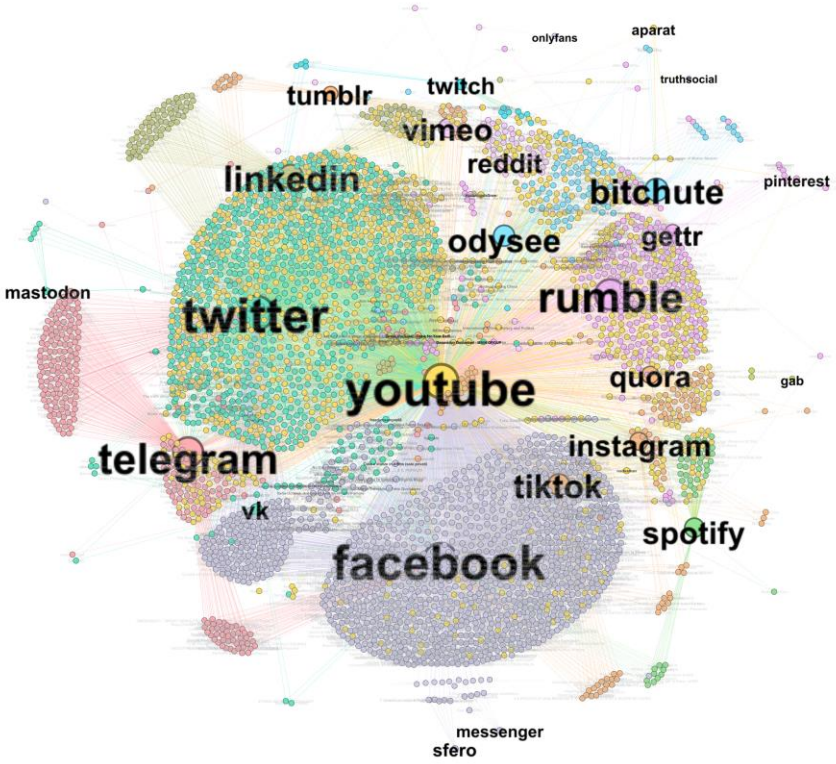


Figure 2. User Platform network calculated starting from X and Facebook that shows the expanded social media ecosystem.

The graph in Figure 2 primarily shows how the fragmentation of the debate shifts toward other online social spaces, each with different characteristics and affordances. On a closer look it also shows a division between traditional platforms (Facebook, LinkedIn, Reddit, Twitter, Instagram), mostly at the bottom, and under-the-radar platforms (Rumble, Gettr, Telegram, Odysee) mostly at the top. The graph also presents some singularities such as Bitchute at the bottom between mainstream platforms and TikTok in the upper part between below-the-radar digital spaces. Another peculiarity is the presence of Twitter (now X) and Telegram in the same cluster; the community detection algorithm places them in the same community, meaning they share an elevated number of users. Acting as a watershed, the center of the graph is dominated by Youtube.com and Youtu.be, the nodes in the graph with the highest eigenvector centrality, i.e., the nodes that possesses the greatest transitive influence in connecting the graph, which can be seen as an importance index for defining the flow of connections.

The Figure 3 below shows a Platform-Topic network which correlates Url domains (from social media platforms but also other platforms and generic websites) to the main topics (extracted with text analysis applied to the text of posts by using NLP algorithms).

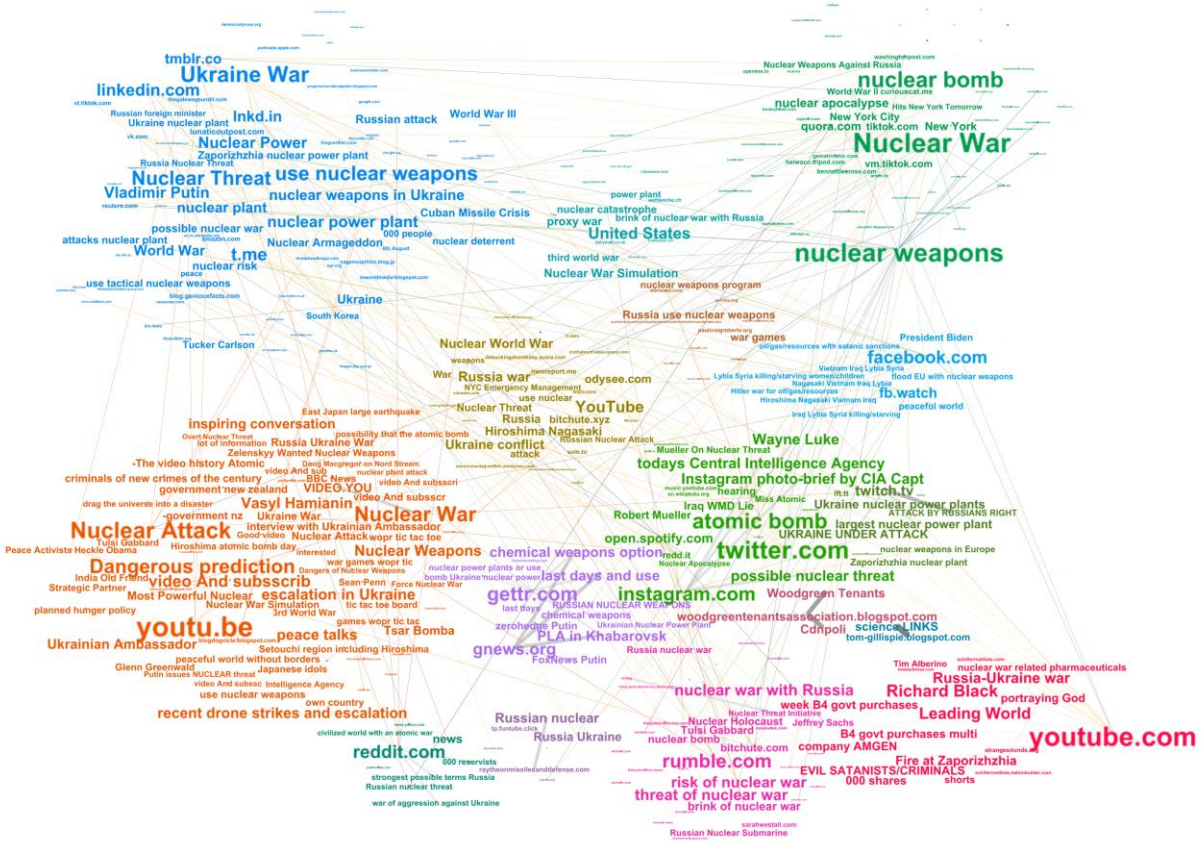


Figure 3. Topic-Domain network calculated to show the fragmentation of the debate.

The purpose of the graph is to show the fragmentation of topics that are diversified and debated on social media along with many different sources of information.

Connected to the Youtu.be domain we can find references to "nuclear attack," "nuclear weapons" (with the Tsar Bomb particularly mentioned) and other references that generally refers to a potential escalation of the conflict in Ukraine. The topics linked to rumble.com and bitchute.com (under-the-radar video sharing platforms) use an highly alarmist vocabulary, using words as "threat" and "holocaust," and contains several references to the U.S. political environment, including partisan journalists such as Tulsi Gabbard and Jeffrey Sachs, news channels such as Fox News, and the alt-right site Breitbart. The blue cluster at the bottom of the graph contains Telegram and LinkedIn as the main platforms and the debate revolves on the use of tactical weapons and nuclear weapons as a deterrent to escalation. Geopolitical perspectives are present with mentions of Vladimir Putin, the Russian Foreign Minister Lavrov, South Korea, and historical events such as the Cuban Missile Crisis. Another topic which clearly emerges is nuclear energy, with references to nuclear power plants, and particularly to Zaporizhzhya. The facebook.com cluster on the left focuses mainly on U.S. politics, with most of the keywords referencing President Biden and some of the famous U.S. conflicts such as Vietnam, Iraq, Libya, and Syria. At the top of the graph, the gettr.com domain contains as the main subject the use of chemical weapons. In the middle of the graph is possible to identify a thematic cluster connected to the video

sharing platforms odysee.com and bitchute.xyz which uses alarmist tones and references to nuclear world war, sharing the thematic with US-based alternative news sources such as AlexJones' infowars, Tucker Carlson, and the Russian news agency RT.com (RussiaToday).

Finally, the graph below shows the aggregate result of the qualitative content analysis which focused on disinformation and partisan content on the sampled datasets. The graph aimed to show the relationships between the different social media platforms encountered and the different positions identified regarding nuclear conflict narrative and its derived subtopics. The goal is to show the level of attunement between partisan perspectives and specific platforms.

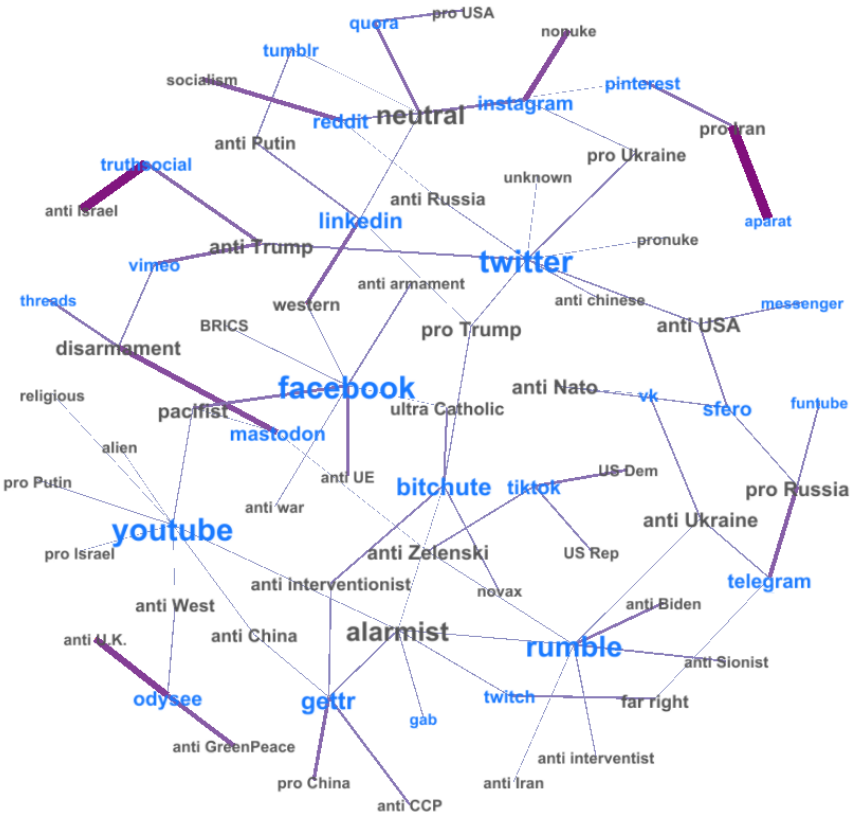


Figure 4. Platform-position network calculated with analysis of the sampled content to show relations between specific positions and social media platforms.

Several insights are visible in the graph. Facebook and Youtube basically show stances relative to different sub-topics that deviate with different nuances and participate in the fragmentation of public discourse. We have insights into geopolitics with anti-Western and BRICS perspectives, religious and ultra-catholic positions, and conspiracy narratives that even introduce aliens into the war equation. In contrast, on Twitter/X it is possible to find aligned positions on the conflict such as anti-Russia and pro-Ukraine, but there is no shortage of other dual perspectives on subtopics such as anti Trump and pro Trump narratives. A peculiarity of the gettr.com platform, on the other hand, is the presence of fragmentation on a specific sub-topic, which discusses both pro-China and anti-China and anti CCP (Communist Party of China) positions. Finally, one part of the graph shows the concentration of various positions espoused against Ukraine around a relatively small number of below-the-radar platforms. The positions are Pro Russia, Anti Ukraine, Anti NATO, Anti Zelenski, and Anti U.S., and are present in a variegated social media ecosystem consisting of video-sharing platforms (rumble.com, funtube), social networks (Vkontakte),

messaging apps (Telegram), and newly developed National social media platforms (the Italian Sfero).

The qualitative content analysis provided the opportunity to focus on disinformation, which, as defined in the methodology section, is used as an umbrella term for hyper partisan content, unverified information, fake news, or conspiracy theories conveyed on different platforms by different actors such as private citizens, politicians, communities, or alternative news channels. We use disinformation as an umbrella term because of the complex scenario that sometimes makes difficult to clearly categorize content as a specific type of disinformation, as in the complexity of the narrative we usually encounter unverified information and fake news that are merged together to shape conspiracy theories aimed at pushing hyper partisan perspectives.

Below are a few examples of such content encountered in the analysis that correspond to what is defined in the literature as disinformation material.

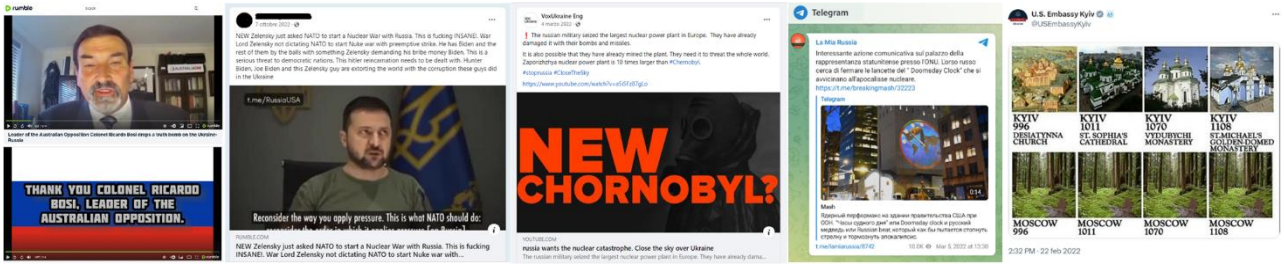


Figure 5. Different examples of disinformation content encountered during the manual analysis.

One example is the Rumble video (82C Army) in which Colonel Ricardo Bosi (2024) is presented as the leader of the Australian opposition, when in fact his Wikipedia page clearly states that he basically founded an unregistered political party). The video contains false and hyperpartisan statements such as "Ukraine is not a sovereign state," unverified (and unverifiable) information such as "the CIA works to harvest Ukraine's natural resources," and conspiracy theories such as "the Deep State has planned a war against Russia." Another example of intentionally misleading content was the rumors of Zelensky's call for a "preemptive (nuclear) strike" during a video conference with the Lowy Institute in Sydney. The news was based on a translation error by the interpreter who corrected himself by saying "preemptive action" (Preussen, 2022). Zelensky's spokesman Sergii Nykyforov clarified in a Facebook post that the Ukrainian president was referring to economic sanctions, but misinformation had already polluted the social media ecosystem. An example of unverified hyper-partisan propaganda is the alarmist content regarding "New Chernobyl" at Zaporizhzhia, where Ukrainian sources accused Russian troops of bombing and mined the plant to threaten a nuclear catastrophe. The undermining of the plant was not verified at the time of the post (March 4, 2022) and was not documented until later (July 23, 2023) by reliable sources such as the IAEA (2023). The threat of a nuclear catastrophe turned out to be a misleading alarm intended to increase public opinion attention on the specific issue; the Russian government's goal was actually to connect the plant to the Russian power grid (Murphy, 2023). The last two images refer to hyper-partisan content conveyed by memes. In the first example we have the Russian bear trying to block the doomsday clock and in the last image the Ukrainian embassy shares a historical perspective on the origins of the two countries to mock the opponent.

DISCUSSION

In response to our first research question, the graphs in Figures 2 and 3 respectively show: how the social media ecosystem expands from mainstream platforms such as Facebook and X towards a larger number of platforms with different affordances that allow each user to expand their social discussion space; how a fragmented digital space is characterized by topic fragmentation which follows the platform-specific logics and the influence of different actors that inhabit it.

We have identified some actors who focus on military escalation and the use of atomic weapons, with historical references to Hiroshima and Nagasaki, while others focus more on the risk the conflict could pose to nuclear facilities such as Zaporizhzhya, which is alarmingly compared to Chernobyl. As expected, video sharing platforms (mainly Youtube), attracted the largest volume of information, taking a central role in the heart of the information ecosystem. The analysis underlined the prominent influence that some platforms (Rumble, Bitchute, Gettr) received from the U.S. debate mixing narratives inherent in U.S. politics (Democrats vs. Republicans, Biden vs. Trump) which highlighted hyper partisan actors (Tulsi Gabbard, Jeffrey Sachs, Alex Jones, Tucker Carlson) and alternative-news and traditional news channels acting as Think Tanks (Foxnews, Breitbart, Infowars). These platforms are alternative video sharing platforms used to upload content-which has been previously, or would be-banned from Youtube, letting content creators express the more extreme positions in the polarization spectrum of debate. Other platforms (Telegram, VK, Sfero) are more likely to present points of view from the Russian perspective, conveying Kremlin statements, citing Vladimir Putin or Sergej Lavrov, and relaunching Russian news agencies such as RT and Sputnik.

This evidence supports the fragmentation thesis that argues that the exchange of information among users fosters ideological, political or social divisions, leading to the formation of distinct and homogeneous groups (Bright, 2018). As users are exposed to different sources of information, their comments reflect different perspectives and evolve over time, resulting in the fragmentation of discourse into subtopics. The interaction of different viewpoints among these topics and subtopics can exacerbate public opinion, eventually leading to other phenomena such as social or political polarization (Chen et al., 2021). What emerges is a multifaceted declination of the nuclear and atomic narrative, which diverges into various directions encompassing political, historical, military, technological, and energy perspectives. This complexity highlights how the narrative is shaped and reshaped through diverse lenses, highlighting the importance of contextual factors in influencing the debate and the spread of ideas related to nuclear and atomic issues in digital platforms.

Looking in the direction of the platform role in the ecosystem, the research addressed the second research question using the qualitative content analysis, detailing the positions vehiculated in each platform in relation to the main topics and subtopics. The results are summed up in Figure 4, and let emerge the fragmentation dynamics of the social media ecosystem, highlighting the platforms that-more than others-are prone to host extreme positions. These social media spaces are part of a complex media ecosystem, in which users are not limited to the use of mainstream platforms, such as Facebook, TikTok or Instagram,

but combine the use of more marginal or "under-the-radar" platforms, which foster the spread of anti-mainstream rhetoric, promoting alternative worldviews where users are exposed to narratives based on conspiracy theories, fake news, and hyper-partisan narratives. This is the case of Rumble, Telegram, Sfero and Vk, which mainly show positions close to the Kremlin narratives, or Gettr, a video sharing platform in which the influences of the U.S. debate are evident, which have fueled a fragmentation of the discourse from a perspective that looks at China's role in the international arena, recording ambivalent pro-China and anti-China positions. Worthy of attention are some smaller platforms associated with specific individual positions, such as Tumblr-AntiPutin, Aparat-ProIran, Funtube-ProRussia. This evidence points to the hypothesis that, in particular cases, the platforms themselves may be configured as trenches in a Trench Warfare dynamic (TWD) (Karlsen et al., 2017). The logic of TWD suggests how in the complex dynamics of online debates opinions are reinforced through both contradiction (leaning beyond the trench and joining the debate) as well as confirmation (remaining in the trench and configuring an echo chamber). The key point that should be emphasized is how these platforms/trenches, are spaces where disinformation "survives" the content moderation on mainstream platforms, and can be used actively for disinformation dissemination toward other platforms or be used to attract users through bridges that drive attention to these alternative below-the-radar platforms. Some of those alternative platforms are often created with the specific intent of opposing the traditional information dynamics of mainstream platforms, as evidenced in the figure below by the advertisement of the video-sharing platform Bitchute, which explicitly reads "Defund the media. Fund Bitchute."



Figure 6. Advertisement with clear anti-media rhetoric on Bitchute.

These online spaces present themselves as places of "freedom of expression" or "counter-information," but they often become fertile ground for the spread of extreme perspectives pushed using populist, conspiratorial, or anti-establishment rhetoric that strongly contribute to eroding trust in institutional information (Park et al., 2020).

In addressing our third research question, it can be concluded that the synergistic use of both mainstream and alternative platforms presents a potential challenge to the effective implementation of the Digital Services Act (DSA) in combatting the spread of disinformation. A clear definition of "disinformation" or "harmful content" is notably absent in the Digital Services Act (DSA), with the term "disinformation" being mentioned only 13 times across the 156 appendices and entirely absent from the 93 articles of the DSA. This lack of precise terminology poses challenges in creating a consistent framework for addressing the issue. Recent studies have already underlined as critical aspects how harmful content/information and disinformation remains basically undefined within the DSA (Husovec, 2024; Leiser, 2023; Fathaigh, Helberger and Appelman, 2021). The DSA recognizes disinformation as a phenomenon that can generate far-reaching systemic risks, threatening social cohesion, public safety and democratic stability, and imposes strict

measures on digital platforms to "tackle illegal content, online disinformation or other societal risks" (European Commission, 2022).

Systemic Risks are situations in which digital services can generate or amplify far-reaching negative effects on users, society, and democracy. The systemic risks are defined in the Article 34 of the DSA (European Commission, 2022) and particularly concern risks related to: dissemination of illegal content (terrorism, hate crimes, child pornography); fundamental rights (protection of freedom of expression and information, media freedom and pluralism, respect for human dignity, and non-discrimination); democratic processes (negative impacts on elections, civic discourse and public security); public health (health-related misinformation, such as during the COVID-19 pandemic or to a person's physical and mental well-being); manipulation of online services (algorithmic manipulation, exploitation of personal data, or promotion of scams and fraud).

Not all platforms have the same obligations to address Systemic Risks. The DSA defines VLOPs (Very Large Online Platforms) as the Online Platforms having over 45M active users (Facebook, Youtube, X, Instagram among others). These are considered to have a wide influence on public opinion and society as a whole and have increased obligations to address Systemic Risks, but some scholars underlined the regulation creates risks through uneven obligations by differentiating across online providers (Laux, Wachter and Mittelstadt, 2021). The presence in the information ecosystem of below-the-radar platforms (such as Rumble, Bitchute, Mastodon, Telegram, Sfero, Gettr, Odysee, Gab, VK, Funtube, Aparat etc.) that are categorized as Online Platforms and have few obligations is potentially detrimental to the effective application of the Digital Service Act (DSA). The Online Platforms which are not VLOPs have lighter obligations such as duty of care to misuse for illegal activities (Article 23 DSA); transparency of Terms & Conditions and recommender system (Article 24 DSA); implement notice and action mechanism for users (Article 16 DSA); are required to "prioritize" trusted flaggers (Article 22 DSA), which are entities representing collective interests and independent of any online platform, possessing particular expertise and experience for the purposes of detecting, identifying, and notifying illegal content (Leiser, 2023). Trusted flaggers are appointed by the Digital Services Coordinator of the member state where the applicant is established (Art. 19). As underlined by recent literature the regulatory distinction risks to overlook the dangers coming from smaller below-the-radar Online Platforms (Nannini et al., 2024; Laux, Wachter and Mittelstadt, 2021) since they can still propagate disinformation and foster discrimination even with fewer user (Diaz Ruiz, 2023). With this research we aimed to expose their deletery position in the social media ecosystem.

While recognizing the logical and logistical choice to prioritize the scrutiny on those platforms hosting a larger number of users (as explained in Appendices 75 and 76 of the DSA), it is nevertheless necessary to point out that the disparate treatment of platforms can result in favoring smaller platforms, which in the information ecosystem, however, can configure extremist niches, making it more difficult to uniformly enforce laws and protect users across the European Union. The spread of disinformation and illegal content is not an isolated problem on individual platforms, but is the result of a complex connection between digital spaces. Regulation and management of platforms must therefore take this complex ecosystem into account, developing strategies that can address disinformation in an integrated way, intervening on both the most visible channels and the marginal ones, which are often more difficult to monitor.

CONCLUSION

Even considering the cross-platform nature of this research, a limitation of this study comes from platform-specific bias that arises by relying on Facebook and X/Twitter as mainstream platforms from which start the exploration, as these platforms present specific user demographics and behaviors that can influence the results. Additionally, Facebook content comes only for public pages, public groups, and verified profiles due to Meta's policies on privacy. However, it should be emphasized that content shared in Facebook public groups and pages usually comes from profiles belonging to everyday users, allowing us to have a representation of this type of users in our datasets. It should be clarified that both Facebook and X/Twitter engage in content moderation and censorship, which may result in the removal of harmful or disinformation-related posts, leading to an underrepresentation of certain discussions or behaviors in the dataset. Furthermore, the temporal limitations of network analysis based on static snapshots may miss the evolving nature of online interactions, hindering a comprehensive understanding of long-term dynamics in disinformation patterns.

Nevertheless, the atomic conflict narrative developed in concomitance with the war in Ukraine provided an interesting case study to comprehend the complex dynamics that characterize the critical role that social media plays in shaping public opinion and influencing political debate. This study highlights the complexities of addressing disinformation in the increasingly fragmented online landscape, where both mainstream and alternative platforms contribute to the circulation of harmful content.

The Digital Services Act represents a significant step toward regulating large platforms, yet its limitations regarding smaller, under-the-radar platforms leave critical gaps in governance, allowing disinformation to potentially "survive" content moderation, and later continue to spread and propagate bias by bridging social spaces filled with extreme content. To mitigate the spread of disinformation effectively, a more nuanced regulatory approach is required—one that encompasses the full spectrum of platforms, adapting to the evolving dynamics of digital communication.

Effectively addressing these challenges requires a multifaceted and collaborative approach involving not only internet platforms and government agencies, but also civil society and traditional media (Surjatmodjo et al., 2024). Such collaboration is key to mitigating the spread of harmful content and establishing a healthier, more resilient digital ecosystem capable of promoting informed public debate and reducing the influence of false or misleading information.

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Interuniversity Doctoral Programme in Urban and Regional Development

Social media ecosystem and disinformation.

The dynamics of the debate on nuclear energy, radioactive waste and the atomic conflict narrative.

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Supervisor

Prof. Sara Monaci

Politecnico di Torino – Università degli Studi di Torino

September 16th, 2025

Conclusions Index

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2. **Key Findings from the case studies**
3. **Final Discussion and Implications for future research**
4. **Conclusions**
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1. Overview

This doctoral research explored the dynamics of disinformation within the social media ecosystem by attempting to highlight how the complex ecosystem of platforms can influence the dynamics of content dissemination in a fragmented and polarized environment. By examining how disinformation circulates across mainstream and below-the-radar platforms, the study reveals the multiplatform dynamics that shape the spread of misleading narratives, especially concerning complex and high-stakes topics like nuclear energy and atomic conflict.

In the case of nuclear energy, disinformation often emerges in the form of exaggerated risks or deceptive claims about the environmental impact of nuclear power and its safety. The study explores how these disinformation campaigns not only thrive on alternative platforms (such as Telegram, Rumble, and Gab) with less stringent content moderation but also gain traction on mainstream digital spaces due to the interconnectivity between platforms. These dynamics highlight the difficulty of isolating disinformation, making it essential to look at the issue through a broader lens that spans the entire social media ecosystem. The research underscores how false narratives about nuclear energy, often fueled by ideological and political motivations, can spread faster when actors exploit gaps in content regulation and moderation across various platforms.

The study also examines the role of disinformation in the context of atomic conflict, where misinformation about nuclear warfare, policy decisions, or geopolitical tensions can exacerbate public fear and polarization. The research reveals how disinformation agents exploit the evolution of social media dynamics, adapting their strategies to bypass regulatory measures, and how they use both mainstream and fringe platforms to target specific audiences. This insight is crucial for understanding how such disinformation can affect public opinion and policy, particularly in the context of sensitive global issues like atomic conflict.

In addition, the research sought to highlight the limitations of some regulations in the presence of cross-platform content dissemination dynamics. As evidenced by recent studies (Surjatmodjo, Unde, Cangara, & Sonni, 2024), regulations alone are not sufficient to contain the problem, but must be assisted by counteracting actions such as fact-checking and digital literacy. For this reason, the main objective of this research is to emphasize the importance of a coordinated use of various technical, educational, and political strategies within below-the-radar platforms, which by their very nature can more easily be configured as environments of origin and nurturing of deleterious social dynamics that represent a potential threat to the integrity of democratic processes and social cohesion.

2. Key Findings from the case studies

The main contribution, which examines the 2022 Italian general elections, reveals the disinformation circulated among public opinion in Italy concerning nuclear energy and the broader narrative surrounding atomic conflict. Social media platforms have increasingly become central to both social and political life, serving as primary sources of information for large segments of the population. These platforms have significant power in influencing or even altering public opinion (Bratton, 2014; Zuboff, 2019), as they provide an arena where diverse content, including news, personal opinions, and public statements, can spread rapidly (Tucker et al., 2018).

This article uses the three adjectives (affective, defective, and infective) to underline the main communicative elements identified through the quanti-qualitative analysis. The term affective emphasizes a communicative style whose aim is to establish a connection at the emotional level with the target audience, privileging feeling, emotion, and affective involvement over objective reasoning or clarity of facts. The term defective, on the other hand, highlights the poor quality of information, including inaccuracies, distortions (intentional or unintentional) and omissions, which contribute to various forms

of disinformation. These shortcomings undermine the credibility of the message, potentially encouraging the perpetuation of false narratives. Finally, the term infective refers to the strategic dissemination of content across multiple platforms with the goal of leveraging digital networks and social media ecosystems to maximize virality and diffusion, facilitating rapid dissemination among diverse audiences.

Together, these three adjectives provide a comprehensive analytical framework for examining how communication strategies manage to simultaneously exploit the emotional dimension, spread fallacious information, and leverage digital infrastructure to improve visibility and content circulation. A central aspect of this paper is to highlight how the combination of these three different aspects of disinformation content is articulated across a wide range of platforms, including traditional social media, under-the-radar online spaces, video-sharing websites, and instant messaging applications.

The study confirms the existence of a certain level of "porosity" between platforms, meaning that the boundaries between them are permeable to information which flows across platforms through user activity, often without significant restrictions. This porosity complicates efforts to fight disinformation within a single platform because once it is shared across multiple platforms, it becomes more difficult to track, manage, or mitigate. This phenomenon suggests that disinformation campaigns can exploit the varied affordances of both mainstream and below-the-radar platforms to maximize the reach and the potential impact of the shared content (Marwick & Lewis, 2017). By directing the attention from mainstream platforms like Facebook, Twitter (now X), and Instagram, towards below-the-radar and less-regulated spaces such as Telegram, Rumble, Mastodon, or Gab, disinformation actors can target their audiences while avoiding the scrutiny of mainstream platforms.

The simultaneous use of mainstream and below-the-radar platforms has become a key tactic for disinformation agents, as it allows them to optimize its visibility and appeal and simultaneously escape content moderation measures that have been strengthened on major platforms in response to growing regulatory pressure. Mainstream platforms, which face more stringent oversight from both internal content moderation policies and supranational regulatory efforts (e.g., the European Union's Digital Services Act), have implemented stricter rules to mitigate the spread of disinformation. However, this can inadvertently drive disinformation actors to use alternative platforms with fewer content restrictions, enabling them to shelter their content from more rigorous moderation (Rogers, 2017) and maintain the attention of fragmented audiences (Benkler, Faris, & Roberts, 2018). As a result, the simultaneous use of mainstream and alternative platforms serves as a powerful tool in the disinformation ecosystem, helping these actors to persist in their efforts to manipulate public opinion. The synergic use of mainstream and below-the-radar platforms partially undermines the effectiveness of regulatory efforts, as content that is removed or flagged on one platform can continue to thrive in others, extending its lifespan.

The study recognizes disinformation as a complex, adaptive issue that goes beyond individual platforms, spreading across a multiplatform ecosystem (Wilson & Starbird, 2020), and underlines how this diverse social media landscape complicates efforts to regulate and ensure the accuracy of the information being circulated.

While the first contribution explores the public debate on a national scale, including the geopolitical dimension and the role of disinformation in social media, the second contribution narrows the scope of analysis to local conflicts related to the National Radioactive Waste Repository. This passage highlights how global dynamics, such as Europe's Green Deal or the energy crisis triggered by the war in Ukraine, intersect with local concerns, where fears about environmental and socioeconomic impacts amplify the NIMBY (Not In My Back Yard) phenomenon, outlining a complex picture of interactions between global and local scales.

Methodologically, this paper illustrates how digital methods and machine learning techniques can be employed to uncover different facets of the debate by mapping the spatial distribution of participants, analyzing their networks, and identifying the key issues under discussion. This work helped explore the dynamics of debate fragmentation and polarization by looking at the impact they can have on local contexts and showed promising avenues for understanding complex social phenomena. The results show

the convergence of diverse actors—spanning various political affiliations, grassroots movements, media outlets of different scales, and trade associations—united under a common position against the Depot that has been labeled NIMYR (Not In My Region). This contribution underlines once again that media ecology of disinformation has changed over time from print media to radio/television and recently to online news and social media (Shu et al., 2017), there is more political information being shared than ever before, with ordinary citizens now playing an active role in the news ecosystem (Tucker et al., 2018).

This study highlights how public debate on social media, although an important platform for democratic confrontation, can generate decision-making stalemates that negatively affect the implementation of strategic public works. Project delays are attributable not only to technical or bureaucratic reasons, but also to a context of local hyper partisan opposition involving public authorities and citizens' committees. The latter, often fueled by the virality of the debate on social media, express concerns related to environmental, economic and safety issues. On the one hand, local institutions show reticence in taking political responsibility for accommodating the infrastructure on their territory; on the other hand, community pressure, amplified by digital communication, has contributed to building a climate of distrust towards the project.

The situation is representative of a broader dynamic: public dialogue, instead of fostering convergence toward shared solutions, risks fueling polarization and hindering decision-making. This scenario calls for reflections on the role of public communication and the need for strategies to balance listening to local demands with the urgency of pursuing interventions of national interest. Italy's experience with the national radioactive waste repository raises crucial questions about public participation and governance that are all the more urgent in a context in which the risks arising from radioactive waste management fragmentation cannot be ignored for long.

The third contribution shifts the attention to an international perspective, where the implications of the Russia-Ukraine conflict redefine nuclear narratives, exploring the digital battleground of the conflict which relies on information manipulation. The contribution reveals how topics fragment across platforms in the media ecosystem, exposing how certain platforms are more likely to host more extreme viewpoints or radicalized content. This finding suggests that while information moves fluidly across platforms, not all platforms are equally receptive to all types of content. Some of these channels are digital spaces where disinformation can survive content moderation and continue to spread. For example, below-the-radar platforms or those with less stringent moderation policies may act as incubators for extremist discourse, which can then be disseminated to more mainstream platforms via hyperlinks or shared content. This dynamic highlights the role of platform-specific affordances, such as anonymity, content moderation, and user base characteristics, in shaping the types of information and narratives that proliferate within specific social media spaces.

A clear distinction emerges between mainstream platforms and below-the-radar ones. Mainstream platforms are integrated into the broader mass media landscape, while below-the-radar platforms are more marginal, often embodying alternative, fringe, or countercultural storytelling that challenges norms and promotes dystopian, critical, or radical perspectives that complicate the understanding of important issues in the public domain (Bennett & Livingston, 2018) such as the current geopolitical crisis. These alternative platforms often provide more permissive environments, either because they lack sufficient moderation infrastructure or because they prioritize free speech over content regulation (Frenkel & Decker, 2021). For example, Telegram's end-to-end encryption and group chat capabilities allow disinformation to spread in private, difficult-to-monitor spaces. Similarly, Bitchute and Gab have positioned themselves as platforms for users seeking fewer content restrictions (Mahl, Zeng, & Schäfer, 2023).

This adaptability creates a scenario where disinformation can survive and persist even when disrupted on larger mainstream platforms. For instance, a false narrative that originates on a below-the-radar platform may spread to a mainstream platform in a shaped form. Alternatively, disinformation quashed on Facebook might reappear on Telegram or in encrypted group chats, where it thrives

unchecked (Tidy, 2021). Thus, it is crucial to track the multiplatform dynamics of disinformation campaigns to understand how these narratives adapt, resurface, and evolve (Ahmed et al., 2020). By moving to alternative or below-the-radar platforms, disinformation promoters can continue spreading their narratives without encountering the same levels of resistance as on mainstream platforms (Frenkel & Decker, 2021).

From this research it emerged that some platforms were created with the specific intent of opposing traditional media (Bitchute or Gab for example), and despite this crucial aspect, they are subject to less oversight by regulators. This observation raises critical questions about the regulation of digital platforms in Europe (such as the recent Digital Services Act) and invites further reflection on governance in this sector. Focusing only on larger platforms creates a false sense of control over the disinformation problem and risks overlooking its cross-platform evolution. If analysts and policymakers focus exclusively on mainstream platforms, they may miss crucial developments and lose the opportunity to counter disinformation preemptively (Persily & Tucker, 2020).

3. Final Discussion and Implications for future research

The three articles in this collection highlighted disinformation (used as an umbrella term that encompasses a number of interconnected phenomena, including misinformation, propaganda, unverified information, fake news, hyperpartisan news, and conspiracy theories). All of these interconnected forms of disinformation are central to understanding how misleading narratives circulate and evolve, fragmenting debate within the social media ecosystem and causing users to struggle to distinguish between credible and deceptive information, contributing to the distortion of public understanding of important issues (Bennett & Livingston, 2018).

The fragmentation phenomenon became central to this work. The fragmentation thesis refers to the idea that the exchange of information between users leads to ideological/political/social division and the formation of different homogeneous groups (Bright, 2018). Several empirical studies on social media (Quattrociocchi, Scala, & Sunstein, 2016; Yardi & Boyd, 2010) have shown that some degree of fragmentation exists. Chen et al. (2021) point out that interaction among individuals is often initiated by the outbreak of a socially significant event that prompts the rapid dissemination of relevant information across the Internet, typically generating discussions from diverse perspectives. Individuals engage with various dimensions of the topic, and their participation contributes to the formation of personal attitudes toward the issue. Influenced by heterogeneous information sources, users' comments reflect a wide range of viewpoints and evolve over time, resulting in the fragmentation of discourse into distinct subtopics. The dynamic interplay of opinions across these topics and subtopics can intensify public discourse, eventually reaching a climax and potentially leading to the polarization of public opinion (Chen et al., 2021). As empirically proven by Bright (2018) this dynamic can also be self-feeding by creating a loop in which polarization and fragmentation reinforce each other. The intersection of these notions gives rise to the concept of multi-polar polarization (Martin-Gutierrez, Losada & Benito, 2023) which highlights the fragmentation of society into multiple distinct and competing groups rather than a simple binary division. Fragmentation can be understood as both a cause and an effect: it is a product of the disinformation ecosystem, and it simultaneously acts as a precursor to increased polarization, since when public discourse becomes increasingly fragmented, it creates the conditions for polarization to thrive (Guess et al., 2020).

Therefore, this research led to focus the attention on recent regulatory measures, such as the Digital Services Act (DSA), in order to understand its potential implications in improving transparency on digital platforms, that reflects some effects on regulating disinformation.

The multiplatform nature of phenomena such as disinformation and polarization and their fragmentation in the social media ecosystem leads us to reflect on recent regulatory measures such as the

Digital Services Act (DSA) (European Commission, 2022) and its potential impact. The DSA introduces a novel regulatory framework aimed to create a safer and fairer environment for both users and businesses within the European Union by regulating digital platforms to improve accountability, promote competitiveness and stimulate innovation (Leiser, 2023).

The DSA can be seen as an attempt by the European Commission to bring an end to the radical indifference (Zuboff, 2019) of platforms, which are embedded in a regulatory mechanism that exempts them from responsibility to the extent that they actively cooperate and "[...]pay particular attention on how their services are used to disseminate or amplify misleading or deceptive content, including disinformation" (DSA, Appendix 84) (Leiser, 2023).

This new regime also aims to mitigate the systemic risks that "may have a disproportionate impact in the [European] Union," (DSA, Appendix 76) which are categorized and defined through Article 34 (and Appendices 80, 81, 82, 83, 84). In the definition of Systemic Risks are several issues that fall within the dynamics explored in the current doctoral research, such as protection of electoral processes, civic discourse, media and information freedom, and media pluralism. Under the Digital Services Act (DSA), the responsibility to assess and mitigate systemic risks is explicitly assigned to Very Large Online Platforms (VLOPs) and Very Large Online Search Engines (VLOSEs) (Latham & Watkins, 2023; Laux, Wachter, & Mittelstadt, 2021). These platforms and search engines are characterized by having over 45 million active users within the European Union, representing approximately 10% of the EU population (DSA, Article 33). Categorized as VLOPs and VLOSEs in the interest of our research are different Social Media platforms such as Facebook, Instagram, LinkedIn, Pinterest, Snapchat, TikTok, X (formerly Twitter) and YouTube, that are subject to the most robust obligations.

However, recent studies have already underlined some critical aspects such as how harmful content/information and disinformation remains undefined within the DSA (Husovec, 2024; Leiser, 2023; Fathaigh, Helberger, & Appelman, 2021), and how the regulation creates risks through uneven obligations by differentiating across online providers who might overlook the risks coming from smaller Online Platforms (Nannini et al., 2024; Laux, Wachter, & Mittelstadt, 2021) since they can still propagate disinformation and foster discrimination even with fewer user (Diaz Ruiz, 2023).

This unequal treatment may produce unintended consequences, particularly in the context of disinformation dissemination that can affect below-the-radar online spaces (Telegram, Rumble, Bitchute, Mastodon and Gab). Disinformation is not constrained by platform boundaries; rather, it adapts to platform-specific affordances, shifting between different media formats and environments to evade detection (Micallef et al., 2022). The uneven application of regulatory measures potentially contributes to an even more fragmented ecosystem that is difficult to monitor and regulate (Saurwein and Spencer-Smith, 2020).

This suggests that the DSA ability to contain cross-platform disinformation is limited, and to reduce the overall impact of disinformation across the digital ecosystem, the DSA needs to be complemented by efforts aimed at multiplatform regulation to address the gaps in governance and prevent harmful content flow between regulated and un(der)regulated spaces.

A key point is that most actions to counter disinformation and polarizing perspectives occur after the actual dissemination of the content, automatically resulting in damage limitation. Fact-checking is one of the most important nongovernmental actions and has recently developed in Europe with many organizations that, however, face difficult challenges in countering disinformation (Graves and Cherubini, 2016). Debunking is only one of the activities of fact-checkers, for whom the verification of politicians' public claims plays a preponderant role. Time, funding, and specialized personnel are not the sole prerogative of fighting disinformation. Another aspect to consider is that these NGOs rely on donations and struggle to find a stable model of self-funding. Recent literature (Surjatmodjo, Unde, Cangara, & Sonni, 2024) emphasize the difficulties of effective and comprehensive early detection, which is hampered by the practical impossibility of filtering the content present in the vastness of the ecosystem of digital platforms, underlining the importance of a multidimensional approach to counter

disinformation. Finally, debunking sites do not have large audiences and need mainstream media action to be conveyed. This sets up a framework in which it is difficult for fact checkers to operate and without the help of platforms they cannot combat disinformation at the source (Saurwein and Spencer-Smith, 2020).

The three contributions of this doctoral research illustrate how disinformation agents can exploit the diverse affordances of different platforms to evade content moderation and regulation. This multiplatform strategy not only potentially enhances the spread of misleading content about nuclear energy and its military declination, but also challenges regulatory frameworks, which tend to focus on the governance of individual platforms rather than the broader information ecosystem. As a result, efforts to combat disinformation requires not only curbing the spread of false or misleading content (Vosoughi et al., 2018) but must take into account the increasingly fragmented and articulated nature of online information dissemination in order to mitigate its harmful effects.

Since the circulation of information is the foundation of the public sphere that underlies public debate in a democratic society (Habermas, 1989 [1962]), and digital networks are the foundation of information flow in modern democracies (Castells, 1996), this study would like to indicate future research paths that focus on proactive actions aimed at counter disinformation and polarization based on shaping the social media ecosystem.

Given that this issue is situated, at least in part, at the level of the architecture of online communication, it has been proposed (Durante, 2019) that an effective remedy must similarly operate at this level. Specifically, this involves designing the architecture of online communication to foster serendipity (Sunstein, 2018), the chance for users to encounter diverse content unexpectedly and to be exposed to information they would not otherwise access. Such an approach constitutes a complex and intriguing solution, as it addresses the ethical, political, and epistemic challenges posed by the reduction in the plurality of viewpoints. This intervention operates on what Floridi (2017) terms the procedural or infra-ethical level, focusing on the structural and design dimensions of online communication systems.

The bridges between platforms we used as objects of study in the articles of this doctoral research could be seen as part of the infra-ethical architecture of the social media landscape, influencing how information flows, how users interact with content, and how platforms interconnect. Bridges facilitate Cross-Platform Communication by enabling users to access or transfer content and data across platforms, they create opportunities for greater diversity of information and Counteract Fragmentation, fostering broader exposure to diverse viewpoints.

An idea that would be interesting to develop could be the integration of reliable, institutional, journalistic, and academic news channels into less-visible or so-called “below-the-radar” social platforms. Platforms such as Rumble, Bitchute, or Sfero which fall outside the scope of more stringent regulatory oversight, could potentially represent a strategic environment for conveying verified information. These platforms, characterized by niche user bases present both opportunities and challenges for the dissemination of credible news sources (Gillespie, 2018). This action shapes the ecosystem environment, reducing fragmentation and leveraging these under-the-radar platforms as spaces where trusted sources of information can act as a "bridge-back" offering the users the opportunity to move and shift their attention to more balanced and less polarized discussion spaces.

From a network topology perspective, we can define a more resilient environment as one that contains a greater number of connections in which this information can travel. This peculiar aspect is represented from a network environment that contains more extragroup connections and results being less fragmented.

There are currently no empirical studies that have tried to preside over below-the-radar platforms with institutional, authoritative, academic, or journalistic accounts in order to study long term effects of a similar activity.

The architecture should encourage exposure to diverse and serendipitous content across platforms, however we do recognize this approach presents several challenges and difficulties, but some strands of research have underlined important aspects to consider in order to follow this path. By placing authoritative and verified content from reputable news outlets or academic institutions in such environments, users exposed to disinformation or echo chambers may be encouraged to engage with more factual content (Bright et al., 2020). This strategy is based on the premise that exposure to reliable information, even in less regulated or more polarized spaces, could act as a corrective force against the spread of falsehoods, eventually guiding users back toward more balanced and reliable sources (Lewandowsky et al., 2020).

Implementing this strategy is fraught with challenges. First, access to platforms like Telegram and Mastodon can be limited for external actors, particularly institutional ones. On Telegram, where group dynamics often foster tightly-knit communities, any attempt to introduce external or institutional information may be met with resistance or outright rejection (Rogers, 2020). Mastodon, being a federated social network, operates through individual servers with distinct rules and cultures, creating additional barriers to the introduction of institutional news sources (Zulli, Liu, & Gehl, 2020). These platforms prioritize privacy and user autonomy, features that can make it difficult for accredited institutions to gain both visibility and trust among their users (Zeng & Schafer, 2021). Some platforms (Facebook, Whatsapp, Telegram) have private groups encrypted or difficult to access (Nuraniyah, 2017), and others could operate through community-driven moderation (Reddit or Mastodon for example), meaning that different thematic forums have distinct norms and rules that may be hostile to mainstream media or institutional sources (Massanari, 2015). Pennycook & Rand (2019) highlighted the cultural and ideological resistance of users of these platforms who use these below-the-radar environments precisely to escape what they see as censorship and/or mainstream propaganda showing how simple and straightforward debunking can influence users but also the less effectiveness in polarized environments. The perception of institutional actors as "mainstream" or part of the establishment can fuel distrust among users who are already skeptical of such sources (Hameleers, 2022). The platforms' algorithm could limit the visibility of informational content by favoring sensationalist or polarizing content (Vosoughi, et al., 2018; Bail et al., 2018) making it harder for verified information to gain traction.

Is fundamental to consider the possibility of unintended effects such as further polarizing the debate or pushing some users to migrate to even more decentralized platforms. Other issues to consider are the limited human and technical resources that universities, institutions, and media outlets may have to actively and meaningfully preside over these environments, and also the difficulty of engagement due to different communication norms that may appear unappealing to niche platforms (Marwick & Lewis, 2017). To address these challenges, accounts should modulate tone and language by adapting it to a more congenial communication style, engaging influencers or well-known figures within the platforms. An interesting approach to explore is that of Ecker et al. (2022) who tested the concept of pre-bunking, or preemptive dissemination of correct information to reduce the impact of misinformation. An additional measure could be to not just convey informational content on specific issues, but instead promote content that stimulates critical thinking and verification of sources , helping people understand the dynamics of social media, and thus advancing the goal of digital literacy, which is an important aspect of combating disinformation and polarization.

Therefore, while the idea of using these platforms to offer new paths from fragmented environments and bring users back into more balanced information ecosystems holds potential, the path to achieving this is complex. Success requires not only overcoming access and visibility challenges but also navigating the community and algorithmic dynamics that shape content dissemination on these platforms (Pennycook & Rand, 2019). Finding the right balance between promoting reliable information and respecting platform norms is critical if this approach is to reduce fragmentation and improve the broader information landscape.

4. Conclusions

This doctoral research underscores the growing complexity of disinformation in the digital age, where disinformation no longer stays confined to individual platforms but rather flows seamlessly across the entire ecosystem of social media. The cross-platform dynamics of disinformation demand a more nuanced approach to combating it, one that goes beyond the scope of existing regulations, which often fail to address the full scope of the problem. As evidenced in this study, disinformation actors are adept at exploiting gaps in platform policies, migrating from mainstream platforms to alternative or below-the-radar spaces where they can operate with fewer restrictions. This adaptive strategy not only enables the spread of false narratives but also challenges the very framework of content moderation and platform governance.

One of the key findings of this research is the importance of looking beyond mainstream platforms to understand the full scope of disinformation campaigns. Platforms such as Telegram, Rumble, and Mastodon, while under the radar in terms of regulatory oversight, play a crucial role in nurturing polarized and radicalized environments. By focusing only on larger, more regulated platforms, we risk missing critical developments in disinformation spread and public opinion manipulation. Therefore, any strategy to counter disinformation must embrace a holistic, multiplatform approach, considering the entire information ecosystem rather than isolated parts.

Furthermore, this study highlights once more the importance of proactive, early-stage interventions. Traditional efforts to combat disinformation, such as fact-checking and debunking, often occur after content has spread, limiting their effectiveness. Future research and policy strategies should explore ways to intervene earlier in the content dissemination process, possibly by leveraging the unique dynamics of below-the-radar platforms to introduce reliable, institutional, and verified information. Integrating such sources into these spaces could serve as a corrective force, encouraging users to engage with balanced narratives and reducing the polarization that fuels disinformation.

At the same time, it is crucial to recognize the challenges inherent in this approach. Below-the-radar platforms often have established user bases that are resistant to mainstream narratives, and the very nature of these platforms—often focused on privacy and user autonomy—can complicate efforts to introduce external information. Moreover, the algorithmic and cultural dynamics of these platforms, which often prioritize sensationalist or polarized content, may limit the visibility of reliable sources, creating additional barriers for corrective actions.

Despite these challenges, this research points to the necessity of shaping a more resilient information ecosystem, one that is less fragmented and more interconnected. By strategically placing trusted, verified sources within these environments, we can create bridges that encourage users to move from polarized spaces to more balanced discussions. However, this requires not only overcoming access and visibility barriers but also respecting the norms and communication styles of these platforms. Tailoring content to fit the specific dynamics of each platform, engaging influencers within these spaces, and promoting critical thinking through initiatives like pre-bunking and digital literacy could help mitigate the impact of disinformation and foster a healthier information environment.

In conclusion, the challenge of combating disinformation is complex, requiring a multifaceted approach that integrates technical, educational, and policy-based strategies. This research contributes to the ongoing conversation by emphasizing the need for a broader, cross-platform perspective on disinformation and proposing actionable strategies for fostering resilience in the digital public sphere. By leveraging below-the-radar platforms as spaces for promoting reliable information, we can help bridge the divides in our fragmented information ecosystem and support the integrity of democratic processes and social cohesion in an increasingly digital world.

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