

A Methodological Framework for Examining Sociotechnical Imaginaries during the implementation of emerging technologies

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Abstract

In the social sciences, there is a growing interest in how people imagine and interpret the impact of technology, captured by the term "Sociotechnical Imaginaries." This concept highlights society's collective tech expectations can influence policies, investments, and mobilizing resources. The study proposes a methodological approach to analyse these imaginaries based on a digital, mixed and sequential design with different phases: it starts by reviewing European documents on new technologies to identify regulatory models among countries. Then, it involves discussions with experts across sectors to understand their views on technology and its societal implications. The final goal is to create an Opinion Dictionary via hybrid Opinion Mining, providing a tool for innovation researchers to map out narratives central to technological futures. This methodology aims to uncover the narratives driving society's technological expectations and their transformation processes, offering valuable insights for policymakers and analysts.

Keywords: *Sociotechnical imaginaries, Narratives Analysis, Emerging Technologies, Digital Methods.*

1. Introduction

In the field of social sciences, there has been an increasing focus on exploring how social actors perceive and anticipate technological innovations. Jasanoff and Kim (2015) introduced the notion of "Sociotechnical Imaginaries," which are collectively held visions and expectations regarding technology's future role and impact within a society. Beginning with a contemplation of current technological states, these scenarios lay out a horizon of expectations that, while not guaranteed to be fulfilled, are nonetheless capable of mobilizing resources currently, legitimizing political decisions, guiding strategic investments in specific sectors, and initiating

social dynamics. Thus, the capacity of social actors to envisage the technological future is not merely theoretical but also has performative aspects (Borup et al., 2006). The examination of narratives has recently zeroed in on their role in fostering projectivity (Andersen et al., 2020) and their utility in probing imaginaries concerning the technological future. Narratives about the future can vary depending on the temporal aspect (e.g., they might lead to alternating cycles of excitement and disillusionment), the type of technology and the change it promises, and the communities of actors engaged in the discursive practice of sharing or contesting expectations about the future (Borup et al., 2006). Social actors share divergent narratives, form distinct expectations about the technological future, and endeavor to translate these expectations into conceivable imaginaries (Mager and Katzencach, 2021). Therefore, in an era marked by rapid technological and social changes, grasping the future's imaginaries through narratives is crucial for anticipating potential evolutionary scenarios and steering public policies. This underlines the necessity for an analytical approach that leverages discursive practices to delve into expectations around emerging technologies and digital transformation processes. The research presented herein seeks to bridge this gap to develop an analytical framework capable of semi-automatically reconstructing the narratives that underpin imaginaries on the technological and digital future, to comprehend how future expectations can direct change processes.

2. Methodological Path and Analysis Phases

This study falls within the Science and Technology Studies (STS) domain, specifically within the STS branch that focuses on the construction processes of sociotechnical scenarios. By "emerging technologies," we refer to technological innovations at an early development stage with significant potential to profoundly impact society, the Economy, and culture. These technologies typically exhibit rapid changes, high uncertainty, and often significant ambiguity regarding their future applications and implications. The concept of emerging technology is dynamic, evolving as innovations surface and others mature to become integrated into daily life (Rotolo et al., 2015). The research addresses the following questions in detail: Q1 - What kind of sociotechnical future is envisioned in narratives about technologies? Q1- Which socio-technical imaginaries are developed about emerging technologies? Q2 - Which governance and transformation processes do these relate to? Q3 - Which actors are involved? Q4 - How do the imaginaries among different actors and in relation to different technologies vary? To address these questions and meet the overall goal of developing an analytical approach that leverages discursive practices for exploring expectations concerning emerging technologies and digital transformation processes, the research was structured around a sequential exploratory methodological approach employing digital and mixed methods. This approach is divided into four phases summarized in Figure 1.

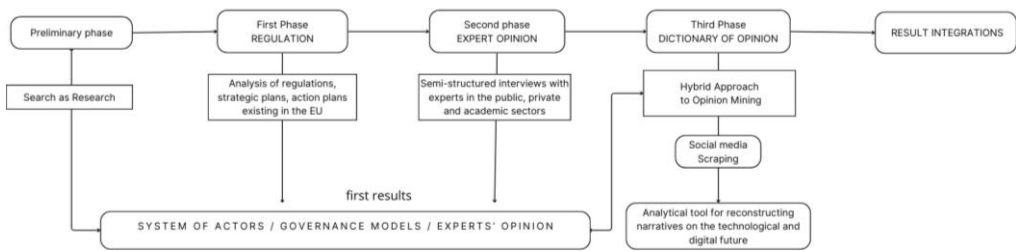


Figure 1: Research Design

At this point we will describe all the phases of the research and illustrate the proposed analytical model. Being a work in progress, we are currently working on the second analysis phase, the results of which will be presented at the conference.

2.1. Preliminary Phase. Defining the Investigation Field

This phase is grounded in the "Search as Research" approach (Salganik, 2019), which posits that online search activities, including search queries and navigation patterns, can serve as valuable data sources for digital social research. This methodology was employed to establish the parameters and boundaries of the research, trace trajectories of interest, and define the field of investigation. This phase aimed to delineate the research context, identify the technologies to be analyzed, pinpoint European countries that have adopted or initiated regulations, strategies, or action plans concerning these technologies, set the time frame, identify data collection sources, and determine search keywords. The selected time frame encompasses the last five years, during which the EU has increasingly engaged in consultations on emerging technologies. The technologies identified as fitting the "emerging technologies" category include Artificial Intelligence (AI), Robotics, High-Performance Computing (HPC), Digital Twins, and Automated Decision Support (ADS). As an initial step for each technology, it was necessary to identify the online sources for gathering existing documentation under investigation. Beginning at the European level, all online portals provided by the European Community offices and the European Parliament were identified, offering official and comprehensive access to legal and legislative documents, reports on action strategies, and investments by the EU and its member countries. For some identified technologies, EU portals are exclusively dedicated to them (e.g., for AI), featuring national chapters for each member state (plus Norway and Switzerland, but excluding the UK) with detailed and updated factsheets on adopted policies and respective national strategies. Each national factsheet includes information from the Organisation for Economic Co-operation and Development (OECD), which systematically collects and presents data on the regulatory strategies of countries worldwide, including policies, governance guidelines, and financial support. The OECD.AI dashboards also offered valuable guidance for navigating the national portals of the United Kingdom, which are excluded from the European

chapters The OECD sources were also a valid support for orienting oneself among the national portals of the United Kingdom, excluded from the European factsheets. Ultimately, the European Commission and the OECD provide general guidelines for governments that still need to publish such documents. For each identified technology, keywords were generated (in appendix) to initiate web search queries on national ministerial sites. To build the list of keywords, Google Trends was a valid support; it has been used as a source of information for new topics of interest concerning emerging technologies. OECD dashboards have also been useful: these use real-time data to show timely trends on where, how and at what pace new technologies are being developed and used, and in which sectors. National strategies for implementing quantum technologies were encountered during the search for regulations/action plans on HPC, leading to their inclusion among the technologies under investigation.

2.2. Frist Phase. Existing Regulations in Europe Regarding Emerging Technologies

The first phase of analysis involves collecting and examining existing official documents on regulations, national strategies, and action plans across various European countries. This aims to identify guidelines, actors involved, and governance practices at the individual country and European community levels. The goal is to define standards, procedures, and guidelines for implementing and using technologies. This process highlights common and divergent positions useful for identifying policy models that guide change and strategic planning. Generally, ethical and social considerations are integrated into policies, strategies, and regulations, emphasizing the importance of responsibly managing emerging technologies. Governance elements—including ethics, privacy, security, monitoring, data management, research and development, innovation, inclusion, and professional training—may vary in scope and nature depending on national priorities, available resources, and the socio-political context. By comparing the policies and development plans of different member states, we expect to discern specific guidelines and practices adopted at both the national and European levels, offering a clear picture of how emerging technologies are managed. This comparison aims to highlight the similarities and differences in each country's approach to technological advancement, enhancing understanding of the current context to assess future trends and directions in technology regulation that drive change processes. Identifying specific strategic and regulatory models characterizing groups of countries positions the subsequent focus on Italy as a pilot investigation that could be expanded to other European nations, considering the emerged models. Based on the keywords and government sites identified in the previous analysis phase, we proceeded with the document collection. On many of the websites consulted, it was possible to conduct a thorough search using various filters, including the period, general theme (education, Economy, innovation, healthcare, etc.), and document type (this filter generally helped to exclude press reviews and journalistic articles from search results). In total, 165 documents were collected as follows: 66 documents relating to AI, 19 documents relating to Quantum Technologies, 18 documents relating to HPC, 14 documents relating to Robotics, 12 documents relating to Digital

Twins, and 36 documents relating to legislation national of the Member States that have implemented the GDPR, 9 of which have provisions regarding Automated Decision-Making Systems (referred to as art. 15 and Article 22 of the GDPR). For some countries, some documents were found to be updated versions of the same implementation plan; in this case the most recent document was considered (table 1).

What emerges is that we cannot yet talk about "regulation" about these technologies but more generally about "national action plans", "strategic plans", "development plans", etc. In the context of the development and implementation of emerging technologies at the national level, these terms describe documents and initiatives that guide a country's approach towards adopting the technology and its regulation. Although the two terms seem similar, it is possible to highlight slightly different purposes and contents: a National Strategy establishes a country's long-term vision regarding the development and use of technology. A national action plan (or agenda) is a more detailed document that sets out specific steps (how and when), initiatives, projects and resource allocations to achieve the objectives outlined in the national strategy. As is partly evident from the table, almost all EU countries have a national implementation plan for AI and Quantum Technologies. For HPC, most European countries refer to the EuroHPC program, and the search for national documentation certainly shows the presence of infrastructures in the area (super computers) but not national strategies or actual regulations; rather these documents concern financing plans or project tenders. For robotics, regulatory research, strategies and action plans almost always lead back to AI regulations. In fact, as stated in the document *European Civil Law Rules In Robotics* of the European Parliament Committee on Legal Affairs (2016), artificial intelligence is considered as an underlying component of "intelligent autonomous robots" (ibid. pp. 11-21) and therefore thought of as something that allows the autonomy of robotic technological systems and not something different from them. Similarly, for Digital Twins, national documents refer to data protection laws starting from the GDPR (General Data Protection Regulation), and subsequent implementations. "Digital twins" as digital representations of physical systems, processes or services are governed by the same laws that govern the use of digital data, especially those related to privacy protection and security. The European Union legislation intended to protect the personal data and privacy of individuals within the EU and the European Economic Area. Also for automated decision-making systems (ADS/ADM) the applicable general principles are to be found in the national provisions of the Member States that have accepted the GDPR on data protection and also regulated automated decision-making processes (therefore prohibitions, exceptions and guarantees). The GDPR is in fact an important reference when it comes to automated decision-making and profiling processes as well as adequate guarantees to protect people from this type of processing. The art. 22, paragraph 2, letter. b explicitly refers to any form of processing of personal data that uses automated systems, including algorithms and machine learning models, without human

Table 1. Technologies' documents collected for each European country (plus Norway and the United Kingdom)

	AI	Quantum Tecnologies	HPC	Robotics	Digital Twins	National Provisions on art 22 GDPR (ADS)
EU	X	X	X	X	X	X
Austria	X	X				X
Belgium	X					X
Bulgaria	X					
Cyprus	X					
Croatia						
Denmark	X	X		X		
Estonia	X					
Finland	X	X				
France	X	X	X	X		X
Germany	X	X				X
Greece						
Ireland	X	X				X
Italy	X	X				
Latvia	X					
Lithuania	X					
Luxembourg	X					
Malta	X					
Norway	X		X			
Holland	X	X				X
Poland	X					
Portugal	X		X			
United Kingdom	X	X		X	X	X
Czech Republic	X					
Romania	X					
Slovakia	X					
Slovenia	X					X
Spain	X		X	X		
Sweden	X	X				
Hungary	X					X

intervention. The GDPR Europeanising data protection but delegating significant power to Member States to shape the regulatory landscape within their jurisdiction (Mayer-Schönberger and Padova 2016, p. 325). Given this initial evidence, to meet the research objectives, the documents will be analyzed through Content Analysis forms built starting from European documentation.

2.3. Second Phase. Focus on Italy: The Experts' Opinions

Through semi-structured interviews, the goal of this research phase is to engage in in-depth discussions with experts on the various technologies identified, aiming to understand their technological expectations, change processes, and the broader impact these technologies may have on the future of Italian society. Experts will be selected from the private sector, public sector, and Italian academia, considering their different roles, including managerial and technical positions. The process will begin by identifying leading companies (both private and public) in the sector and university departments dedicated to researching the technologies of interest. From this, the initial group of interviewees will be formed, consisting of academics and managers. The process will then proceed with snowball sampling, asking them to facilitate contact with technicians (in companies), and other professionals or experts with different perspectives, backgrounds, or specializations (in academia). This approach aims to understand how experts envision the future of various technologies in the country, offering an in-depth view of the future technological and digital landscape in Italy. This provides crucial insights to comprehend and navigate a rapidly evolving context. It will enable the identification of emerging trends and technological development processes that experts believe could significantly impact the future. The interviews are expected to shed light on the challenges and opportunities Italy might face in the technological realm and discussions on the ethical, social, and cultural implications of new technologies. An important aspect could be comparing expectations of what technology can achieve and practical realities, such as technological limitations and available resources, potentially leading to policy recommendations. Ultimately, the interviews should also offer valuable insights into how experts communicate the complexity of the investigated technologies to non-experts.

2.4. Third Phase. Construction of an opinion dictionary

Once the governance policies, the system of actors involved and the opinions of experts have been identified, data will be extracted from social media and processed through Natural Language Processing (NLP). Most studies using Opinion Mining techniques have focused on domains other than the one we intend to explore here; no dictionaries contain the necessary contents and concepts to process information about expectations, visions, and orientations regarding the digital and technological future. To generate empirical evidence, an opinion dictionary specific to this domain is needed. The data sample for dictionary construction will be

extracted from major social media platforms (Facebook, Twitter, TikTok) and instant messaging apps (Telegram), taking a cross-platform perspective into account to consider how the different structures of platform discussion spaces affect user experiences around shared narratives. Data will be collected using web scraping techniques based on specific keyword queries for each relevant technology, within a specific timeframe. An LDA topic modelling will be performed on the textual elements of the sample, automatically providing a topic variable for each post, and features will be extracted. The most significant words will be manually labelled based on their orientation towards the future (positive, negative, or neutral polarization), the expectations they promote, the visions they convey, and the discussed change processes. The opinion dictionary will thus include a set of words for each category. The machine learning approach will enable the labelling of the entire sample and verification of the classification's accuracy through a series of synthetic indicators. An opinion dictionary will be created through this hybrid approach (combining supervised and unsupervised methods), becoming an essential tool for reconstructing shared narratives on digital and technological transformation in the Italian context. The analytical path described is summarized in the model indicated in figure 2.

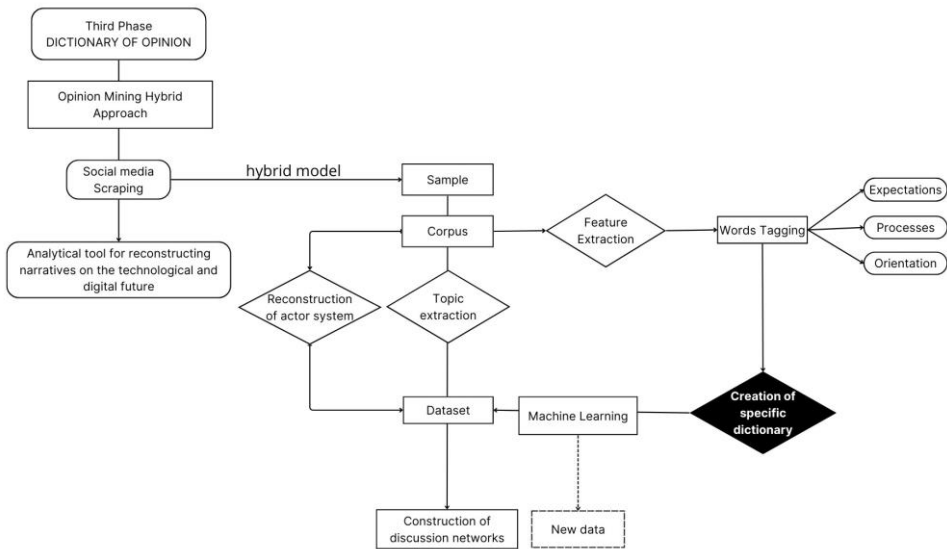


Figure 2. Model of Hybrid Approach to Opinion Mining

3. Conclusion

Through this methodological path, for each technology identified, it will be possible to: identify particular regulatory models that characterize groups of countries and this makes the subsequent focus on Italy a pilot investigation that can be extended in the future to other European nations,

taking into consideration the models that have emerged; understand how experts imagine the future of different technologies in the country, offering an in-depth view of the future technological and digital landscape in Italy and providing essential information to understand and address a rapidly evolving context; build a specific dictionary in Italian that allows the semi-automatic reconstruction of narratives on the technological future through which to investigate socio-technical imaginaries. The dictionary become a replicable tool for the semi-automatic reconstruction of narratives available for other scholars and innovation analysts.

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